POWER

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Capability

ALL men have their limitations, but how many of us work up to ours?

The man who did continuously and habitually the best of which he was capable, would shine in any walk of life.

It is that kind of concentration and painstaking effort that constitute genius and produce results that people admire and applaud.

Many of us are satisfied to do only what we have to and to do that well enough to get by—and no better.

But the man who works up to his capabilities will be surprised to see how competent he really is; how with real interest and application a task will develop in the doing; how it will present opportunities for the exercise of ingenuity and originality which he did not suspect that he possessed.

Many an accomplishment that has made its author rich or famous could have been performed equally well by many another if he had only thought of it and gone to it.

And many a man has remained obscure and penurious because he did not put the best that there was in him into the opportunity that was ready at his hand.

F. R. Low

Small Industrial Plant Generates Current at Low Cost

The Cincinnati Factory of the American Can Co. Uses Combined Heating and Generating Plant—Unaflow Engines Produce Current for Less Than One Cent Per Kilowatt-Hour—Labor Reduced to the Minimum

THE question as to the most economical way to obtain heat and power for an industrial plant is a live one. That, under proper conditions, a factory can by choice of equipment and operating force operate its own power plant at a cost well under that obtained when current is purchased and low-pressure steam used for heating, is evidenced by the operating history of the machinery factory of the American Can Company.

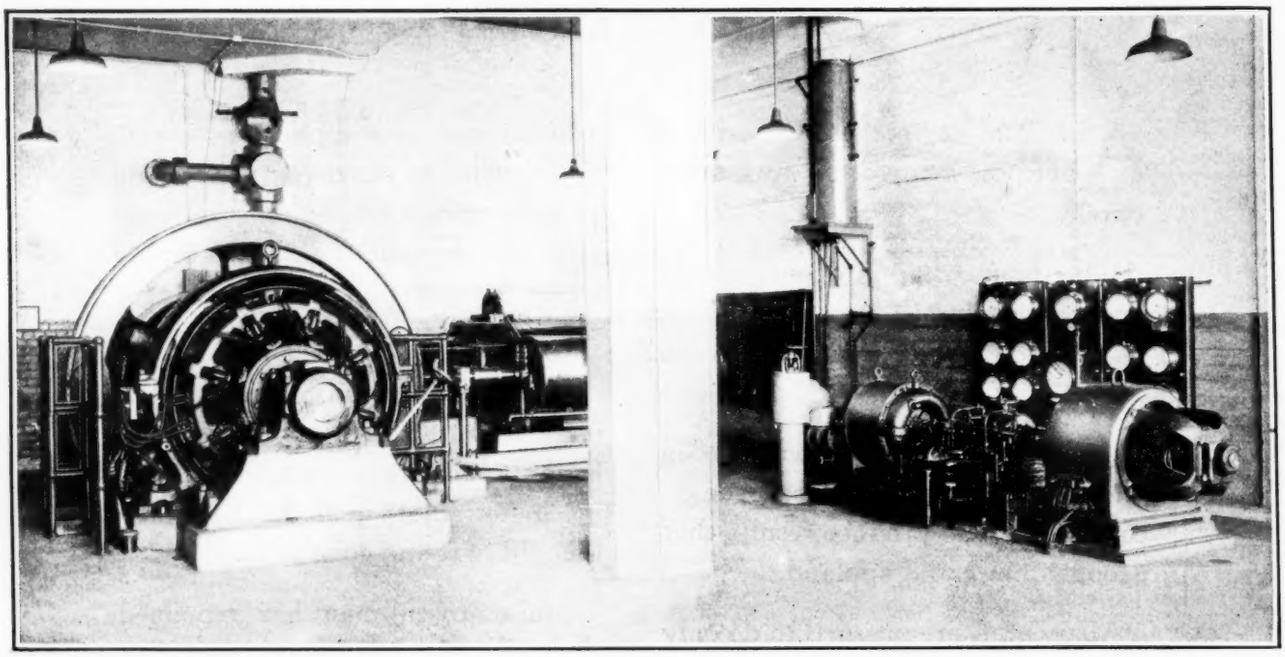

Fig. 1—First unaflow installed and 75-hp. turbo lighting unit

When this concern decided to build a new factory at Cincinnati, Ohio, to be devoted to the building of can-making machinery, the question of generated versus purchased current was gone into very exhaustively. While electrical rates obtainable were low, investigation indicated that since heating was required for at least six months yearly, and some live steam all the year, the factory could generate power at an advantage.

Study of the heating requirements led to the choice of hot water in preference to the direct use of the exhaust steam coming from the prime movers. In this system water is passed through two closed heaters by a single-stage centrifugal pump and is heated by the exhaust from the engine. The hot water then passes through the building heating mains and radiators. After giving up its heat, it flows back to a hotwell, or receiver from which it is picked up by the centrifugal pump and again sent through the system. To insure continuity of service two pumps are provided; the motor-driven unit is operated most of the time, the turbine-driven pump being held in reserve. At night the steam coming from the small turbine-driven lighting set is insufficient to heat the building, consequently live steam is fed to the heaters through a reducing valve. On occasions when the exhaust exceeds the heating requirements, the excess escapes through an atmospheric relief valve, and in summer the engines operate with atmospheric exhaust.

The hot-water heaters are mounted on a steel balcony, Fig. 3, behind the feed-water heaters, while the centrifugal pumps are placed under the balcony.

Two horizontal water-tube boilers having a total of 4,670 sq.ft. of heating surface were installed with underfeed stokers. Forced draft is supplied by a single fan belt driven under normal conditions by a 5-hp. direct-current motor, but a vertical high-speed engine is placed in line with the fan pulley and in case of breakdown the engine can be hooked up to the fan. From the fan pulley a belt drives an overhead lineshaft that is connected to the stoker-control mechanism.

The boiler pressure is controlled by a damper regulator having a rheostat control over the fan motor and a regulating valve on the fan engine, and in this way not only alters the draft-fan speed but also the stoker-

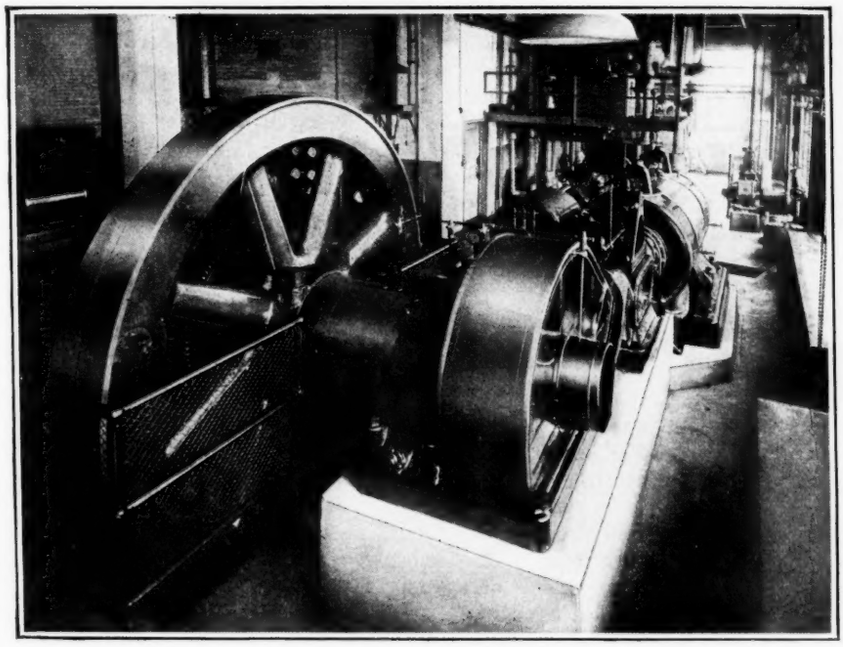

Fig. 2—300-kw. unaflow-generator unit, with heating equipment in the background

ram operation through the driving pump speed. The exhaust from the engines, in addition to heating the water for the heating system, enters an inductive-type open heater. The condensation from the water heaters and the drips from the engines are led to dumping traps which discharge into a storage tank mounted above the boilers. This water is fed to the open heater as needed, the heater having too small a storage to take the trap dumps direct without part overflowing into the waste pipe. To obtain high efficiency, the boilers were fitted with superheaters, two different makes being used. The boilers carry 175 lb. gage pressure with 150 deg. superheat. All flanges on the main steam and water lines are welded, and the piping is covered with one-inch 85 per cent magnesia covering over which is sewed a canvas jacket.

The coal bin is on a level with the boiler room and holds nine carloads of coal, unloading being performed by a conveyor. The fuel is handled into the boiler room on a small wheeled lorry or car, and after being weighed on a platform scale set flush with the floor, is shoveled into the stoker hoppers.

While superheated steam was desirable for the engines, the steam hammers and other factory equipment could not use this high-temperature steam with success, consequently the piping at the boilers was arranged to permit the drawing off of the factory supply before the steam entered the superheater. It was discovered that one of the superheaters would not maintain a steam temperature at all constant, by reason of the variation in the flow to the engine. To correct this, all the steam generated in the boilers passes through the superheaters, and as the factory demand is fairly constant, the fluctuation in the engine demand has less influence on the superheat. The factory equipment is built for saturated steam, and it was necessary to install a desuperheater, which consists of a water-jet device under control of a thermostat. The amount of water introduced is in proportion to the degree of superheat in the steam.

When the factory was built, one 200-kw. unaflow engine direct connected to a three-wire 240-volt direct-current generator was installed to carry the main load. For night-time operation, when the load is lighting exclusively, a 75-kw. turbo-generator unit was also put in. Due to the increase in the power load a 300-kw. unaflow engine direct connected to a generator was installed in 1923. This is in use practically all the time, the load ranging from 700 to 1,200 amperes, and owing to the type of heavy machine tools in the factory sudden changes of 200 to 300 amperes in the demand are not uncommon. The regulation of the engines is such that the voltage variation is slight.

A complete daily log is made of the plant's operation. The flue gases are tested at frequent intervals by an Orsat instrument, the CO_2 averaging from 11 to 12 per cent. The average evaporation is 9 lb. of water per pound of coal, excellent for a plant of this size.

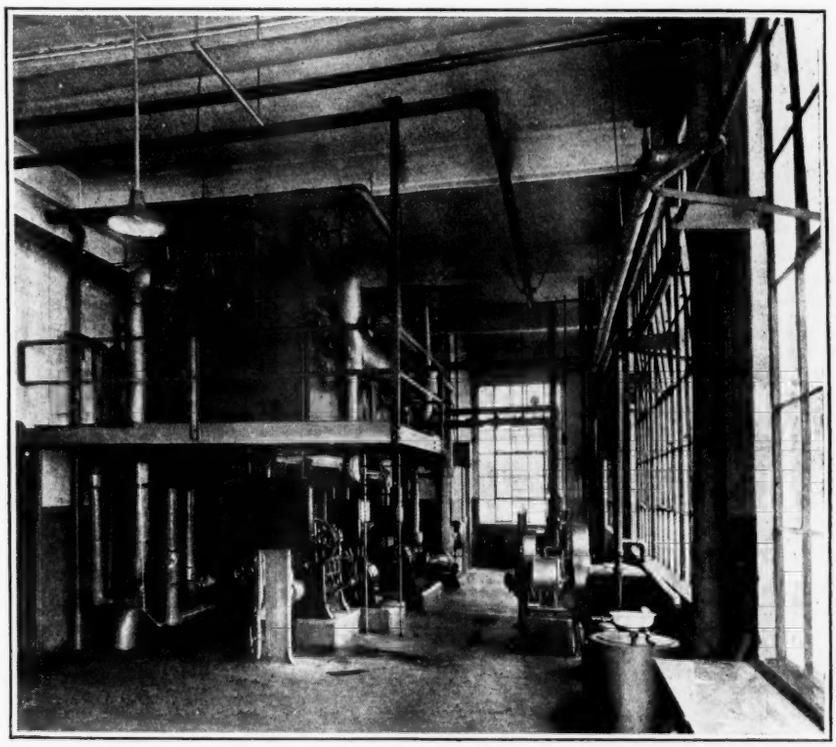

Fig. 3—Hot-water heating system and boiler-feed equipment

In arriving at the cost of generating power, it is necessary to realize that during over half of the year the engine is little more than a reducing valve. The exhaust heat which would be thrown away in a condensing plant is all recovered in the water heaters. In addition, with purchased power all the auxiliaries such as pumps, fan engine, etc., would be needed by the heating and factory system during the entire year. Consequently, the steam used by these auxiliaries is properly chargeable to the factory. The economy of the plant has been very gratifying. The average cost per kilowatt-hour has been under 1 cent and has dropped as low as 8 mills.

The following data show the costs during the month of March, 1924:

Steam generated, daytime, lb.	2,242,800
Night, lb.	1,544,000
Total steam, lb.	3,786,800
Coal, day shifts, lb.	235,489
Night shifts, lb.	174,820
Coal, total, lb.	410,309
Ashes removed, lb.	53,790
Steam pressures to engine, lb. gage	170
Steam pressure to factory, lb. gage	120
Exhaust pressure, lb. gage	0.5
Feed water, average temperature deg. F.	205
Outside air temperature, average, deg. F.	38
Evaporation, lb. water per lb. coal	9.2
Cost evaporation per 1,000 lb. of steam, cents	38.4
Steam to generating units, lb.	1,396,423
Steam to auxiliaries, factory, etc.	2,390,375
Steam consumption, lb. water per kw.-hr.	25
Kilowatt-hours generated	55,857
Fuel per kilowatt-hour, lb.	2.71
Generating costs per kilowatt-hour, cents	0.96

To obtain the highest possible results from the plant, a control board in the engine room is provided with a draft gage of the three-point type permitting the draft in the furnace and in the passes to be read. In addition, the board holds a recording thermometer to show the feed-water temperature, a back-pressure gage, pressure gage for the saturated steam, thermometers showing the hot water system's in and out temperatures and pressure, as well as regulators controlling the temperature of the hot-water heaters. The open feed-water heater is provided with a V-notch meter of the indicating and recording type. In practice, with ½-lb. back pressure the feed-water heater gives a temperature of 212 deg. F., while the same back pressure is sufficient to maintain the factory temperature at 70 deg. in the offices and 65 deg. in the shops. The system has 30,000 sq.ft. of radiation, and the regulators control the temperature with entire satisfaction.

The generating costs include all items such as fuel, oil, repairs, labor, etc., but do not include overhead charges in the engine room. These would add about one-half a cent. The very low generating costs are due largely to two factors. Since the plant must use heating for at least six months and a certain amount of steam in the factory during the entire year, the boiler-room force would be needed even if energy was purchased. The only labor entering into generating costs is that of the engine-room force. In many plants of like capacity the chief engineer would insist on a watch engineer or oiler during the operating shift, but in this plant the chief engineer attends to all the engine-room operating details. If any help is needed, the factory supplies a man, charging the engine room for the expense. Since the addition of an oiler would add appreciably to the cost of generation, other engineers may find in the procedure of this plant a suggestion of how to cut costs. The second factor is the high economy of the engines, which by being given proper attention are able to meet the guarantee figures in every-day operation.

DATA ON EQUIPMENT IN AMERICAN CAN CO. CINCINNATI FACTORY PLANT

Boilers:	
Type	Horizontal water-tube
Size, sq.ft. heating surface	One 2,530; one 2,140
Make	Erie City Iron Works
Setting	Brick
Stokers:	
Type	Underfeed
Make	Jones
Drive	Steam
Draft Fan:	
Make	Underfeed Stoker Co.
Drive	Belted to motor and steam engine
Motor, Fan:	
Make	Gen. Elec.
Size	5 hp.
Engine, Fan:	
Make	Troy Engine & Mach. Co.
Size, cylinder	5 x 7 in.
Horsepower	5
Damper Regulator:	
Make	Hagan Corp.
Heater:	
Type	Open
Make	Swartwout Co.
Traps:	
Type	Dumping
Make	Cleveland
Feed Pump:	
Type	Triplex
Make	Worthington Pump and Mach. Corp.
Size	4 x 6 in.
Drive	Geared to 7½ hp. G.E. motor
Feed-water Regulator:	
Make	S-C Regulator Co.
Standby-pumps:	Steam duplex
Make	Worthington Pump & Mach. Corp.
Size	6 x 4 x 6
Grease extractor:	
Engines:	
Type	Unaflow
Make	Nordberg Mfg. Co.
Capacity	200 and 300 kw.
Size of cylinders	18 x 24 in. and 20 x 32 in.
Generators:	
Type	240 volts, 3-wire d.c.
Make	General Elec. Co.
Filter:	
Type	Continuous
Make	Robinson
Auxiliary Lighting Unit:	
Type	Turbo-generator
Make of turbine	Moore Steam Turbine Corp.
Size, hp.	75
Generator	240 volt d.c.
Make	Burke Elec. Co.
Switchboard:	
Make	General Elec. Co.
Air Compressor:	
Make	Ingersoll-Rand
Size	8 x 8
Type	Horizontal double-acting
Drive	Belted to 15 hp. G.E. Motor
Balancing Set:	
Capacity, kw.	7.5
Make	General Elec. Co.
Heating System:	
Type	Hot water
Make	Grinnell Co.
Water Heaters:	
Make	Griscom-Russell
Hot Water Pump:	
Type	Centrifugal, single-stage
Make	Lea-Courtney
Drive	10 hp. G.E. motor
De Superheater:	
Make	Robert Shaw Co.
Control Instrument Board:	
Draft gage	Bailey Meter Co.
Feed-water meter, type	Recording
Make	Columbia
Back-pressure gage, type	Dial indicating
Motor	Schaeffer & Budenberg
Saturated-steam pressure gage, type	Dial indicating
Make	Schaeffer & Budenberg.
Steam-hammer steam gage, type	Dial
Make	Schaeffer & Budenberg
Cold city water pressure gage	Schaeffer & Budenberg
Air to building thermometer	Dial indicating
Make	Schaeffer & Budenberg
Hot Water System, Instruments:	
Out-water temperature, thermometer	Recording
Make	Schaeffer & Budenberg
Return-water temperature, thermometer	Indicating
Make	Schaeffer & Budenberg
Pump-suction pressure gage	Indicating
Make	Schaeffer & Budenberg
Pump-discharge gage	Indicating
	Schaeffer & Budenberg
Heater back-pressure gages	Two, indicating
	Schaeffer & Budenberg
Heat regulator for heaters	Powers

Figuring a New Winding for an Old Direct-Current Machine

Developing a New Armature and Field Windings for a Direct-Current Machine When No Winding Data Are Available

BY A. C. ROE

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WHEN developing a new winding for an old machine, in some cases the frame will have the old name-plate, from which the machine rating may be obtained. When the name-plate is missing, the question arises, What rating can be obtained from the frame? The armature's peripheral speed in feet per minute and its volume in cubic inches are the two chief deciding factors in the machine output. The volume is equal to $0.7854\ D^2L$, where D is the armature diameter in inches and L the length of the iron in the core in inches.

The peripheral speed of any armature is equal to its diameter D in inches times the revolutions per minute S, times 0.2618. The safe limit for peripheral speed is about 5,000 ft. per min., therefore the safe maximum speed is

$$S = \frac{5{,}000}{0.2618D} \qquad (1)$$

In order to arrive at a safe rating for any frame Table I was compiled for a range of existing motors of a good standard make. In this table are listed 27

TABLE I—DIMENSIONS AND RATINGS OF ARMATURES

Diameter D in Inches	Length L in Inches	Maximum R.p.m.	Maximum Hp.	Conservative Rating R.p.m.	Conservative Rating Hp.
5	2¾	3,600	2	2,100	1¼
5½	3	3,400	2½	2,000	2
6	3	3,200	3¼	1,900	2¼
6½	3¼	3,000	4⅛	1,800	2½
7	3½	2,700	5⅛	1,600	3
7½	3¾	2,500	6¼	1,500	3½
8	4½	2,400	8⅜	1,500	5½
8½	5	2,200	10⅜	1,450	6¼
9	5½	2,100	13¼	1,400	8
9½	6	2,000	16¼	1,350	10
10	6¼	1,900	18¾	1,300	11¼
10½	6½	1,800	21½	1,260	12¾
11	6¾	1,700	24½	1,190	14¾
11½	7	1,600	27¾	1,120	16½
12	7⅛	1,580	32	1,100	19¼
12½	7¾	1,530	36½	1,000	21¾
13	8	1,470	40½	975	24⅝
13½	8¼	1,420	45	975	27
14	9	1,370	53	950	31¾
14½	9	1,320	56¾	950	34½
15	9⅛	1,280	64	925	38½
15½	9⅜	1,240	68½	925	41
16	10	1,200	76½	900	46
16½	10½	1,160	85⅜	850	51½
17	11	1,130	95¼	825	57
17½	11	1,090	101	800	60½
18	11½	1,060	112	750	67¾

Maximum R.p.m. $= \frac{5{,}000}{0.2618D}$; Maximum Hp. $= 0.03D^2L$; Conservative R.p.m. = Maximum R.p.m. x 0.6 to 0.70; Conservative Hp. = Maximum Hp. x 0.6 to 0.70

different armature diameters ranging from 5 to 18 inches and from 1¼ to 12 hp., depending upon the size and speed of the armature. The first column on the left lists armature diameters in inches, the second column lengths of the armature in inches, the third column maximum speed, the fourth column the rated horsepower at maximum speed, the fifth column what would be considered a normal speed, and the sixth column gives the horsepower rating at the normal or conservative speed given. Since the horsepower rating of an armature varies approximately directly as its speed, ratings at speeds other than given in the table can be easily figured from the expression $S_n : S :: HP_n : HP$, from which

$$HP = \frac{S \times HP_n}{S_n} \qquad (2)$$

where HP is the horsepower desired, S the desired speed, HP_n the conservative horsepower rating as given

TABLE II—CIRCULAR MILS PER AMPERE ALLOWANCE FOR ARMATURE, SERIES-, INTERPOLE- AND SHUNT-FIELD COIL WINDINGS

Hp.	R.p.m.	Circ. Mils per Ampere: Armature	Series Field*	Shunt Field
¾	1,300	350	950	4,500
1	1,900	250	860	2,500
2	1,700	200	430	1,200
2	950	300	680	2,000
3	1,100	350	840	3,200
3	930	700	1,000	3,600
5	1,000	340	800	2,200
5	860	600	900	3,000
7½	1,350	420	650	1,200
7½	725	650	850	1,500
10	1,250	400	640	850
10	750	600	750	970
15	1,200	450	900	1,200
15	600	700	1,100	1,800
20	1,050	600	800	900
20	600	730	1,100	1,300
30	975	640	840	950
30	600	700	1,200	1,600
50	900	600	650	1,000
50	550	670	720	1,300
75	800	300	600	850
75	525	500	750	1,000
100	750	380	680	1,000

* Interpole windings same allowance as series-field windings.

in the table of armature dimensions, and S_n the speed given in the table corresponding to the conservative horsepower. As a problem assume that an armature has a diameter of 9½ in. and a core length of 6 in. and it is desired to work out a new winding for this armature and operate the machine at 1,200 r.p.m. By reference to Table I, it is found that such an armature has a conservative-speed rating of 1,350 r.p.m. and a horsepower rating corresponding to this speed of 10; then the rating at the desired speed is $HP = \frac{1{,}200 \times 10}{1{,}350} = 9$. If the speed is materially reduced below the normal given in the table, it will also be desirable to reduce the rating somewhat below that obtained by the formula, since the ventilation is not so good at the lower speeds.

Before taking up the problem of design, the values to be used in each part of the machine will be considered. The amount of copper allowed for a given ampere rating will govern the heating and the I^2R losses. The number of circular mils to allow per ampere will generally run between 500 and 600, but may be as low as 300 for small machines, and on high-current machines at low speeds the allowance may be 800 to 1,000 circ.mils. These values apply to the

armature circuit; the allowance for shunt-field coils is considerably higher in general. The greater the copper cross-section in the winding the lower will be the losses and heating. Table II gives values for the circular mils per ampere allowance for high- and low-speed machines from ¾ to 100 hp. for the armature, shunt- and series-field circuits.

The magnetic density in the polepieces, armature core and teeth will require checking to determine whether these parts are being worked within safe limits. The magnetic density in the armature core below the teeth should be between 50,000 and 100,000 lines per square inch, the lower value being for armatures in which the magnetic frequency is high or 30 to 40 cycles. *Magnetic frequency* = (*r.p.m.* × *number of poles*) ÷ 120. In the armature teeth a density of 120,000 to 140,000 lines per square inch is good practice.

In the polepieces the density should be between 40,000 and 50,000 lines per square inch for cast iron, while laminated iron may have a density of 95,000 to 105,000 lines per square inch. The magnetic density in the air gap, which is equal to the total flux per pole divided by the armature-core area opposite a pole, will run between 25,000 and 70,000 lines per square inch. For motors from ¼ to ¾ hp. the density will be 25,000 to 30,000 lines per square inch; for 1- to 15-hp. motors, 40,000 to 60,000 lines per square inch are good average values. Higher values up to 70,000 may be used for large machines, with laminated polepieces. In any case a value of air-gap density should be used that will keep the armature tooth density within the limits of 120,000 to 140,000 lines per square inch, this density being measured at the root of the tooth.

TABLE III—EFFICIENCY AND INTERNAL VOLTS OF 110-AND 220-VOLT MOTORS*

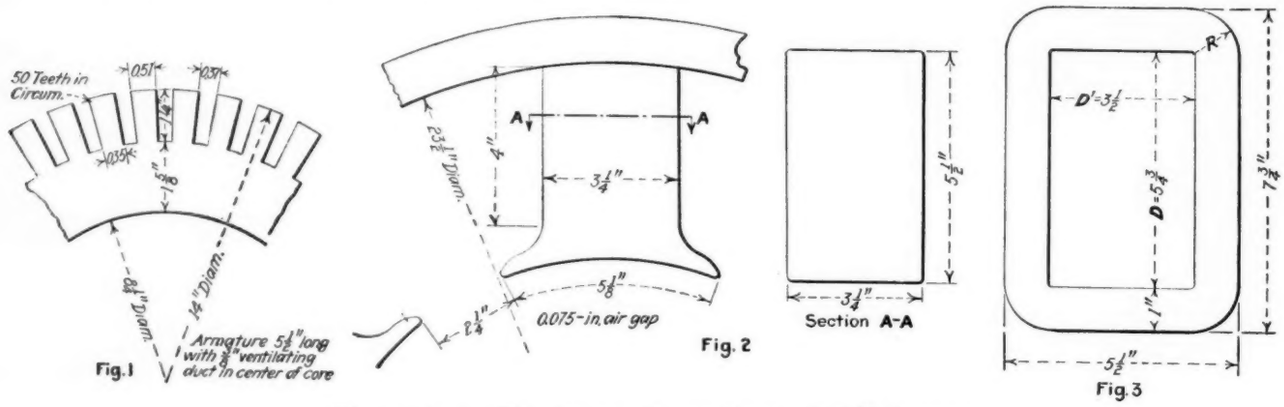
Horsepower	Efficiency	Square Root of Efficiency	110 Armature Volts	220 Armature Volts
¼	0.50	0.707	77.7	155.5
½	0.60	0.775	85.3	170.5
¾	0.72	0.849	93.4	186.8
1	0.75	0.866	95.3	190.5
2	0.78	0.883	97.1	194.3
3	0.81	0.900	99.0	198.0
5	0.84	0.917	100.9	201.7
7½	0.85	0.922	101.4	202.8
10	0.86	0.927	102.0	203.9
15	0.87	0.933	102.6	205.3
20	0.88	0.938	103.2	206.4
25	0.89	0.943	103.7	207.5
30	0.90	0.949	104.4	208.8
50	0.90.5	0.951	104.6	209.2
75	0.91	0.954	104.9	209.9
100	0.91.5	0.957	105.3	210.5

*The internal voltage, or voltage developed by a motor armature, is roughly equal to the square root of the motor efficiency times the line voltage.

The basic formula for armature design is:

The watts $W = 0.0000000016 \times AD^2LB_gKS$ (3)

where A equals the percentage of armature surface covered by poles divided by 100, equals a decimal, which runs between 0.60 and 0.80, a good average being 0.75; D the armature diameter in inches; L the length of armature core in inches; B_g the magnetic air-gap density; K the armature ampere-conductors per inch of circumference; and S the speed of the motor or generator in revolutions per minute. The watts in this formula are the total output or input of the armature and, for a motor are equal to (hp. × 746) ÷ F, and for a generator (Kw. × 1,000) ÷ F, where F equals the square root of the efficiency given in Table III. The first column in Table III gives the horsepower rating, the second column the efficiency, the third column the square root of this efficiency, the fourth and fifth columns the internal voltage that the armature will develop when used in a motor. This internal voltage is less than the line voltage due to the IR drop through the armature and brushes, and is nearly equal to the line voltage times the square root of the efficiency.



Figs. 1 to 3—Dimensions of armature and field frame

In the armature formula there are two unknown quantities, B_g and K; a value can be assumed for B_g and K calculated.

The following data should be taken from the frame under consideration: (1) Diameter of armature; (2) length of iron in the armature core (this measurement should be taken at the bottom of the slot as the teeth flare out and would add considerable to this dimension, depending upon the depth of the slot); (3) depth of slot; (4) width of slot; (5) width and length of polepieces; (6) total height of field-coil space per pole. These dimensions can be put on a rough sketch as in Figs. 1 to 3. The number and sizes of brushes, number of armature slots, and if the commutator is in place, the number of bars should be noted.

For example, assume that a new winding is to be developed for an old 6-pole frame, with the commutator and brush rigging intact but without any field or armature winding. The name-plate is missing, but the machine is to be wound for a 110-volt shunt motor. The commutator has 50 bars and the armature core 50 slots. Dimensions of the armature and field frame are as shown in Figs. 1 to 3. The field poles are made of laminated iron. There are six brush arms with two brush-holders per arm that will take two ½x1⅜-in. brushes.

Table I shows that a conservative speed for an armature 14 in. diameter, Fig. 1, is 950 r.p.m., which will be used. The total length of the armature core is 5½ in. with a ⅜-in. ventilating duct. Looking in Table I at the data for a 14-in. diameter armature, the length given is 9 in., therefore the rating for the armature in the problem will have to be calculated. The rating varies as the length of the armature core, so that in the table if an armature having a core length of 9 in. is good for 31¾ hp. at 950 r.p.m., an armature with a core length of 5½ in. will be good for $31\frac{3}{4} \times 5\frac{1}{2} \div 9 = 19.4$ hp. It will probably be possible to get a winding on the core that is good for about 20 hp., as the slow-speed ratings given in the table are on the conservative side. Therefore, the design will be based on 20 hp., and if necessary it can be changed to a lower value if it is found that the armature slots will not accommodate a suitable winding for this capacity.

Another method of arriving at the rating of an armature core is as follows: The maximum rating is equal to $HP = D^2L \times 0.03$, or in this problem $HP = 14 \times 14 \times 5.5 \times 0.03 = 32.34$. This is based on a maximum speed as obtained by formula (1), which gives maximum speed $S = \frac{5{,}000}{0.2618 \times 14} = 1{,}364$. A conservative speed is about 70 per cent of this value, or $1{,}364 \times 0.70 = 954$, say 950 r.p.m. The rating at the conservative speed is about 60 per cent of the maximum rating, or in this problem is $32.34 \times 0.60 = 19.4$ hp. These values should be taken as only fair approximations to give an intelligent basis on which to develop the design, but may have to be changed after the design of the winding has been worked out to suit the particular machine under consideration.

Calculating Watts Input to Armature

The first step in the design is to figure the watts input to the armature. The efficiency of a 20-hp. motor is, from Table III, equal to 88 per cent. This is the efficiency for the whole machine; the armature efficiency is somewhat higher than this and can be taken as equal to the square root of the efficiency, or in this case $\sqrt{88}$. The watts input to the armature is equal to $(HP \times 746) \div \sqrt{\text{eff.}}$; or in this problem the watts, $W = (20 \times 746) \div \sqrt{88} = 15{,}906$. The full-load current taken by the armature equals watts divided by line volts equals $15{,}906 \div 110 = 145$ amperes.

With a non-interpole machine a current value as high as 200 amperes per path can be used with a wave winding, and for interpole machines this can be as high as 350 amperes. In this case a wave or two-circuit winding can be used. The current per path in the armature winding will therefore be $145 \div 2 = 72.5$ amperes.

There are 6 brush arms with two ½x1⅜-in. brushes per arm, or a total of 12 brushes. One-half of these will be positive and one-half negative, so that 6 brushes will have to carry the total current of 145 amperes. The cross-sectional area of 6 brushes is $\frac{1}{2} \times 1\frac{3}{8} \times 6 = 4\frac{1}{8}$ sq.in., and the current density per square inch is $145 \div 4\frac{1}{8} = 35$ amperes, therefore the size of brush on the machine of the proper characteristics will be satisfactory. Carbon and graphite brushes can be obtained having current-carrying capacities up to about 65 amperes per square inch.

Next check the volts per bar to determine if the 50-bar commutator can be used. Volts per bar equals line volts times number of poles divided by number of commutator bars, or $(110 \times 6) \div 50 = 13.2$, which is a safe value.

In developing the armature winding, assume a value for B_g of 40,000 lines per square inch in the air gap. By measurement it is found that 70 per cent of the armature is covered by the polepieces. By transposition of formula 3, the ampere-conductors per inch of armature circumference $K = W \div (0.0000000016 B_g A D^2 L S)$. In this problem $W = 15{,}906$, $B_g = 40{,}000$, $A = 0.70$, $D = 14$, $L = 5\frac{1}{2} = 5.5$, $S = 950$; then $K = 15{,}906 \div (0.0000000016 \times 40{,}000 \times 0.70 \times 14 \times 14 \times 5.5 \times 950) = 346.7$. Since K equals the number of ampere-conductors per inch of circumference, the total number of ampere-conductors on the armature equals $\pi DK = 3.1416 \times 14 \times 346.7 = 15{,}249$. The total number of conductors on the armature equals the total number of ampere-conductors divided by the current per path in the armature winding, in this problem $15{,}249 \div 72.5 = 210$. The conductors per slot equal $210 \div 50 = 4.2$, or 4 per slot.

A two-layer winding with a diamond-shaped pulled coil is to be used, consequently there will be two coil sections per slot, each section having two conductors, or 2 turns per coil.

Determining Size of Armature Conductors

Next, the size of conductor is determined. Table II gives an allowance of 600 circ.mils per ampere for a 20-hp. machine at 1,050 r.p.m. The current per conductor is 72.5, then the circular mils cross-sectional area required equals $72.5 \times 600 = 43{,}500$. According to the wire table the closest size to this is one No. 4 round wire, which has an area of 41,740 circ.mils, or a No. 4 square with 50,737 circ.mils cross-section; either would make a good winding. One No. 4 d.-c.c. round wire has a diameter of 0.222 in. and No. 4 d.-c.c. square wire has a diameter of 0.227 in. The slot width is 0.37 in.; then $0.37 - 0.222 = 0.152$ in. for insulation when a round wire is used, and $0.37 - 0.227 = 0.143$ in. for the insulation when a square wire is used, which is ample in either case.

There will be four wires per slot, or a slot depth of $4 \times 0.222 = 0.888$ in. is required for the round and $4 \times 0.227 = 0.908$ in. for the square wire. The slot is 1.25 in. deep, then the room for a wedge and insulation equals $1.25 - 0.888 = 0.362$ in. for round wire and $1.25 - 0.908 = 0.342$ in. for the square wire, which is ample space in either case. The armature winding will then consist of 50 coils, each two turns of one No. 4 round or square double-cotton covered wire; one wide by two deep.

A coil pitch of $50 \div 6 = 8\frac{1}{3}$ or 1 and 8 will be used, which is $1\frac{1}{3}$ slots less than full pitch. The commutator pitch will be $(50 + 1) \div 3 = 17$ bars or 1 and 18, which will give a progressive winding. A retrogressive winding cannot be used, since $(50 - 1) \div 3 = 16\frac{1}{3}$, an uneven number.

The total flux per pole $B = 60 \times 10^8 \times EN) \div CPS$; where E equals the internal armature volts, which from Table III for a 20-hp. 110-volt motor is 103.2; N the number of paths in the armature winding, in this problem, 2; C the total number of armature conductors, 200; P the number of poles, 6; and S the speed in revolutions per minute, 950. Then, $B = (60 \times 100{,}000{,}000 \times 103.2 \times 2) \div (200 \times 6 \times 950)$

= 1,086,000 line of force, which enter or leave the armature at each pole. This total flux will be slightly less than 40,000 lines per square inch on account of its being based on the internal volts, or the counter-electromotive force, which is less than the line volts on which the watt input to the armature is based.

The armature diameter is 14 in. and the depth of slot 1.25 in.; then the diameter at the bottom of the slots or tooth root is 14 — (2 × 1.25) = 11.5 in. This gives a circumference of 11.5 × 3.1416 = 36 in. The width of one slot is 0.37 in., and the space occupied by 50 slots is 50 × 0.37 = 18.5 in., which leaves 36 — 18.5 = 17.5 in. to be occupied by teeth. The total length of the armature core was 5½ in. There is a ⅜-in. air duct at the center of the core, which leaves 5½ — ⅜ = 5⅛ in. of iron. The laminations have a thin coating of enamel, so that the total net length of iron can be assumed to be 90 per cent of the measured length, or 5.125 × 0.9 = 4.6125 in. Seventy per cent of the armature surface is covered by the poles; then the net area of iron at the tooth roots is 17.5 × 4.6125 × 0.7 = 57.2 sq.in. From this the magnetic density at tooth roots = 1,086,000 × 6 ÷ 57.2 =

TABLE IV—MULTIPLIERS FOR DETERMINING FIELD AMPERE-TURNS PER POLE, BASED ON ARMATURE AMPERE TURNS PER POLE

Hp.	Shunt Motor	Series Motor	Compound Motor	
			Shunt Field	Series Field
1	2.50	2.10	1.00	0.80
3	2.35	2.12	1.20	0.78
5	2.23	2.15	1.20	0.74
7½	2.12	2.20	1.25	0.72
10	2.00	2.25	1.25	0.68
15	1.87	2.30	1.27	0.67
20	1.75	2.40	1.28	0.65
30	1.62	2.50	1.29	0.63
50	1.49	2.60	1.30	0.60
75	1.37	2.70	1.31	0.54
100	1.25	2.80	1.32	0.47

113,916 lines per square inch, which is well up to the saturation point and is satisfactory.

The net area of iron under the teeth equals 4.6125 × 1.625 = 7.51 sq.in. The flux per pole divides into two paths in the core, therefore the flux in each path will be 1,086,000 ÷ 2 = 543,000 lines. Then in the core the flux density equals 543,000 ÷ 7.5 = 72,300 lines per sq.in., which is a satisfactory value.

Next, the density in the polepieces will be checked. These are laminated, therefore the net cross-sectional area will be 90 per cent of that corresponding to the dimensions, or 5.5 × 3.25 × 0.9 = 16.09, or 16 sq.in. To obtain the total flux per polepiece, the leakage must be taken into consideration. As a general rule the total flux will be 1.2 times the flux per pole, or in this case total flux equals 1.2 × 1,086,000 = 1,303,200 lines per pole. The magnetic density per square inch equals 1,303,200 ÷ 16 = 81,450 lines, which is fair value.

Ampere-Turns Required for Field Coils

The standard procedure of determining the ampere-turns required in the field windings per pole involves the use of saturation curves and plotting the lengths of the various sections of the magnetic paths, their areas and ampere-turns required for each section, which is a complicated and tedious operation. Instead of doing this a short-cut method will be used, which is based on the fact that the total field ampere-turns per pole bears a certain relation to the number of armature ampere-turns per pole. In an ordinary motor or generator the field ampere-turns per pole will be from 1.25 to 2.5 times the armature ampere-turns per pole, the low value being for large machines and the higher values for small machines and the higher values for small machines. This relation also holds for series-, shunt- and compound-wound motors. Table IV gives the average values for shunt and series motors and also the multiplier to use for the shunt- and series-field windings in compound-wound motors.

We are now prepared to calculate the shunt-field windings. The armature ampere-turns per pole equals the total number of coils in the winding times the turns in each coil times the current in each armature circuit divided by the number of poles; then for this case the armature ampere-turns per pole equal (50 × 2 × 72.5) ÷ 6 = 1,208. To find the total ampere-turns required in the field winding per pole, consult Table IV and find for 20-hp. shunt motor. The multiple is found to be 1.75; then 1,208 × 1.75 = 2,114 ampere-turns per pole, which includes the leakage and armature reaction factors.

Size of Wire in Field Coils

To estimate the size of wire, a value must be had for M, the mean length of one turn in the field coils. The dimensions of the polepieces are given in Fig. 2. What is needed is the thickness of the coil, which on an average is 25 per cent of the coil height. In this case the coil height is 4 in.; then the approximate thickness is 4 × 0.25 = 1 in. Allow ⅛-in. space between the coil and iron for insulation, then the approximate dimension of the coil becomes that of Fig. 3. With the dimensions indicated as in the figure, the mean length of one turn $M = [4(D + D') + 2R\pi] \div 2 = [4(5\frac{3}{4} + 3\frac{1}{2}) + (2 \times 1 \times 3.1416)] \div 2 =$ 21.64. The volts per field coil $e = 110 \div 6 = 18.3$. The size wire in circular mils equals ampere-turns times mean length of one turn in inches divided by volts across one coil, or (2,114 × 21.64) ÷ 18.3 = 2,500 circ.mils. The closest to this value is a No. 16 wire with 2,583 circ.mils, which will do. From Table II it is found that an allowance of 900 circ.mils per ampere is sufficient for a 20-hp. motor. Then, the permissible shunt-field current is 2,583 ÷ 900 = 2.87 amperes, which is (2.87 ÷ 145) × 100 = 1.97 per cent of the full-load armature current, and is satisfactory.

Number of Turns in Field Coils

The turns per coil equal 2,114 ÷ 2.87 = 737. One No. 16 d.-c.c. wire has an insulated diameter of 0.06 in. Allowing ⅛ in. at each end of the coil for insulation gives a winding space of 4 — ¼ = 3¾ in. Then the turns per layer equal 3.75 ÷ 0.06 = 62.5, or 62, and the number of layers equals 737 ÷ 62 = 11 layers of 62 turns and one layer of 55 turns, or 12 layers in all. The thickness of the coil = 0.06 × 12 = 0.72 in.

Although the thickness of the coil is approximately ¼ in. less than that assumed, it is not sufficient to cause any material change in the coil, so that it is not necessary to figure it again. If the coil is assumed to be 0.75 in thickness, the length of a mean turn is $[4(5\frac{3}{4} + 3\frac{1}{2}) + (2 \times 0.75 \times 3.1416)] \div 2 =$ 20.85 in. As there are to be 737 turns in each coil, the total length of wire in one coil is 20.85 × 737 = 15,366 in., or 15,366 ÷ 12 = 1,280 ft. The resistance of the coils will vary with their temperature, but taking a temperature of 176 deg. F., a No. 16 copper wire has a resistance of 4.964 ohms per 1,000 ft. Then one coil will have a resistance of (1,280 × 4.964) ÷ 1,000 = 6.35 ohms. The voltage applied to one coil

is 18.3, therefore the current taken by the coil equals $18.3 \div 6.35 = 2.88$ amperes, which is very close to the value previously calculated.

It has been found by experience that the field coils in an open-type motor will radiate about 0.75 watt per square inch of cylindrical area. The circumference of the coil in inches equals $C = 2(D + D^1) + 2R\pi = 2(5\frac{3}{4} + 3\frac{1}{2}) + (2 \times 0.75 \times 3.1416) = 23.21$, say 23 in. On account of the insulation the circumference will be slightly greater than 23 in. The coil is 4 in. wide, so that the cylindrical area equals $23 \times 4 = 92$ sq.in. The watts equal volts times amperes, or $18.3 \times 2.88 = 52.7$ watts. Watts to be dissipated per square inch equal $52.7 \div 92 = 57.3$, which is well within the safe limit.

The winding data for the 20-hp. 950-r.p.m. motor are: 50 coils and bars, two turns of one No. 4 sq.d.-c.c. wire, per coil, coil pitch, slots 1 and 8, lead pitch bars 1 and 18, two-circuit wave winding, shunt-field coils 737 turns of one No. 16 d.-c.c. wire per coil.

Field Winding for a Series or a Compound Motor

Using the same frame, the only difference in the calculations for the windings in a series or a compound motor would be for the field windings. The ampere-turns in these windings can be determined by using the armature ampere-turns and the multipliers given in Table IV for a series or a compound motor, as the case may be. The current in the field winding of a series motor or the series winding in a compound motor is the full-load current of the motor.

In machines having interpole, the ampere-turns per interpole are also based on the armature ampere-turns per main pole. The following formula gives the ampere-turns for each interpole coil when there are as many interpoles as main poles, but when there are only half as many commutating poles as main poles, then double the values found in the formula,

$$\textit{ampere-turns per interpole} = AIT\left[1 + \frac{(3PGL)}{DL_p}\right]$$

where AIT equals the armature ampere-turns per pole, P the number of main poles, G the length of the air gap in inches under the interpole, D the diameter of the armature in inches, L the length of armature core in inches, and L_p the length of the interpole in inches parallel with the shaft.

If the frame under consideration had six interpoles, $4\frac{1}{2}$ in. long with $\frac{1}{8}$-in. air gap under each pole, then the ampere-turns per coil would be $1{,}208 \times \left[1 + \frac{(3 \times 6 \times 0.125 \times 5.5)}{14 \times 4.5}\right] = 1{,}436$. The size of wire and turns per coil are calculated in the same manner as for the series-field winding, using the circular-mil allowance given in Table II. The interpole winding is connected in series with the armature and in such a manner that the interpole polarity opposes that of the armature.

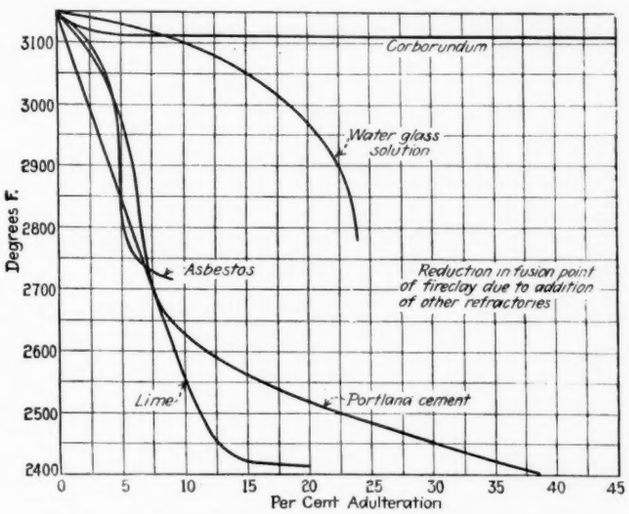
The foregoing formulas and tables will give results that will be correct to within 10 per cent and will be on the conservative side.

One very important point in operating air compressors is to see that the air receiver has all the accumulated oil drained out of it every little while. If too much oil is used or the receiver is not properly drained, gases may be formed which may ignite spontaneously and cause a bad explosion.

Proper Clay for Furnace Walls

By M. S. Gerend

It has for many years been recognized as a cardinal principle in the setting up of boiler furnaces that the mortar or clay in which the firebrick or tile is laid should be equal in strength and heat resistance to that of the brick or tile. In order to avoid having the mortar act as a flux, thereby lowering the fusion point of the brick, it has been found advisable to use a clay or cement having the same chemical characteristics as the brick. Clay or cement having a low fusion point will melt out of the joints, leaving openings through which the furnace gases can attack the brick on more than one face, causing rapid deterioration. Particles



Fusion point of clay when mixed with a binder

of ash will also become attached to the walls by reason of the fluxed clay, causing slag deposits or possibly, fluxing of the brick.

Ordinary fireclay has little mechanical strength, and it has been the custom for bricklayers to add portland cement, silicate of soda and other binders to the clay in order to increase its mechanical strength. As long as the added material does not act as a flux to lower the fusion point of the clay, it may serve a useful purpose, especially in that portion of the furnace which is not subject to a heat that will sinter the clay—that is, cause it to form into a solid mass by heating. Many of the binders have a violent fluxing action on clay, and in order to show graphically the typical lowering of the fusion point of a high-grade clay due to an admixture, the set of curves shown have been drawn: The data covering these curves have been compiled from several sources, largely from Mellon Institute reports.

Applying provisions of the Connecticut tax laws, the Supreme Court of Errors lately decided in the case of Connecticut Light & Power Company vs. Town of Oxford, 126 Atlantic Reporter, 1, that a dam situated partly in one town and partly in another and used in generating power in a plant situated in the latter town, was not taxable in the former town. It was further decided that steel towers carrying transmission lines were not taxable in the towns where erected, but were properly regarded as a part of the machinery of power production in the town where the power was created.

Some Operating Provisions at the Williamsport Station*

Instruments have been chosen and arrangements made with a view to maintaining both economy and service continuity in special ways as described. Generators are to operate in multiple only through transformers.

AN ACCURATE knowledge of what goes on in the plant is essential to efficient operation. Instruments therefore play an important part in obtaining the desired fuel economy, especially with the refinement of equipment characteristic of modern stations.

The Williamsport, Maryland, plant of the Potomac Edison Company utilizes both forced- and induced-draft fans. Feed water is heated by economizers, single-stage

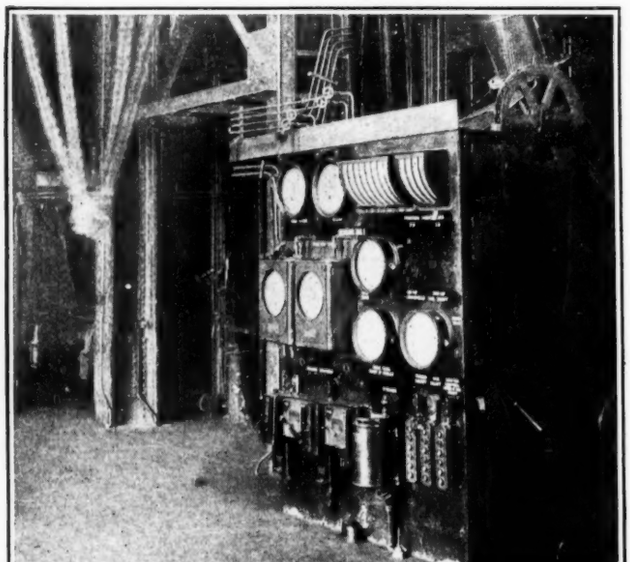


Fig. 1—Control board in front of each boiler

bleeding, and exhaust steam, as previously described. The basic measurements of fuel and total feed water are taken care of in the usual manner. A weightometer checks the former while total feed water is recorded by a venturi meter at the feed-pump gage board. Temperatures, however, are recorded on each boiler control panel, Fig. 1. These are: Economizer water inlet and outlet and gas inlet and outlet, as well as total steam temperature. In addition, flow meters on each panel record the steam output, which may be checked against measurements of feed water, by the venturi meter.

The double-outlet boiler flow meter records steam from one outlet direct and from both totalized, and in addition the volume of gas passing through the boiler. This last feature permits determination of the amount of excess air used.

In one of the draft-gage cases is mounted the scale of the pneumatic-type stoker motor tachometer. This scale has double markings showing the stoker speed proper for any boiler output.

Each fan is direct connected at one side to a slip-ring motor of sufficient size to carry moderate boiler loads, and through a magnetic clutch at the other side to a larger similar motor for the highest loads. The speeds of all fan motors are regulated by motor-driven secondary drums and resistors.

The forced- and induced-draft fans are controlled individually by push buttons. In addition a master controller is provided by which the speed of all fans may be regulated simultaneously by one operation. Arrangements have been made so that automatic control of combustion may be added if desired. The two motors of each fan are handled as a single unit, automatically transferring from the small to the large motor and engaging the magnetic clutch as the load increases.

Since the speed-controlling rheostats are mounted close to the variable-speed fan motors, it is desirable to show at the control boards the positions the rheostats take in response to the push buttons. For this purpose dial-type electric position indicators are mounted on the boiler-control boards, showing the control point on which each fan motor is operating.

In regulating the fan speeds for a given boiler load, it is more convenient to speak of the speed in terms of controller notches than of revolutions per minute. The attendant can readily set the controller at the position required for a given load. This simplifies his work, because if he were ordered to adjust in terms of speed he would have to translate this into terms of controller notches. It has the further advantage that, since the heavy induced-draft fans change speeds slowly, requiring some time to produce a variation on the draft gages, the position indicators save time by showing immediately the response to the push buttons.

A number of instruments not connected to the individual boilers are conveniently grouped on a gage board near the feed pumps. These include, besides the feed-pump gages, the essential instruments connected to the deaërating equipment and evaporators and indicating gages for the feed-water heater and turbine extraction pressures.

In the turbine room most of the indicating instruments are placed directly on the main unit itself, requiring the presence of the operator directly at the machine. This not only facilitates inspection, but provides a necessity for the operator to visit the turbine at regular intervals in order to read and record such readings. The gage board near the main turbine contains a synchronism indicator and an indicating wattmeter. Temperatures of generator cooling air, both inlet and outlet, are here recorded.

Among the instruments provided for condenser operation is a three-pen temperature recorder showing the exhaust-steam temperature, that of the condensate and also of the circulating-water discharge. This has an inverted scale, with the low-temperature portion near the outer margin of the chart where the graduations

*An account of this station at Williamsport, Maryland, appeared in the March 4, 1924, issue.

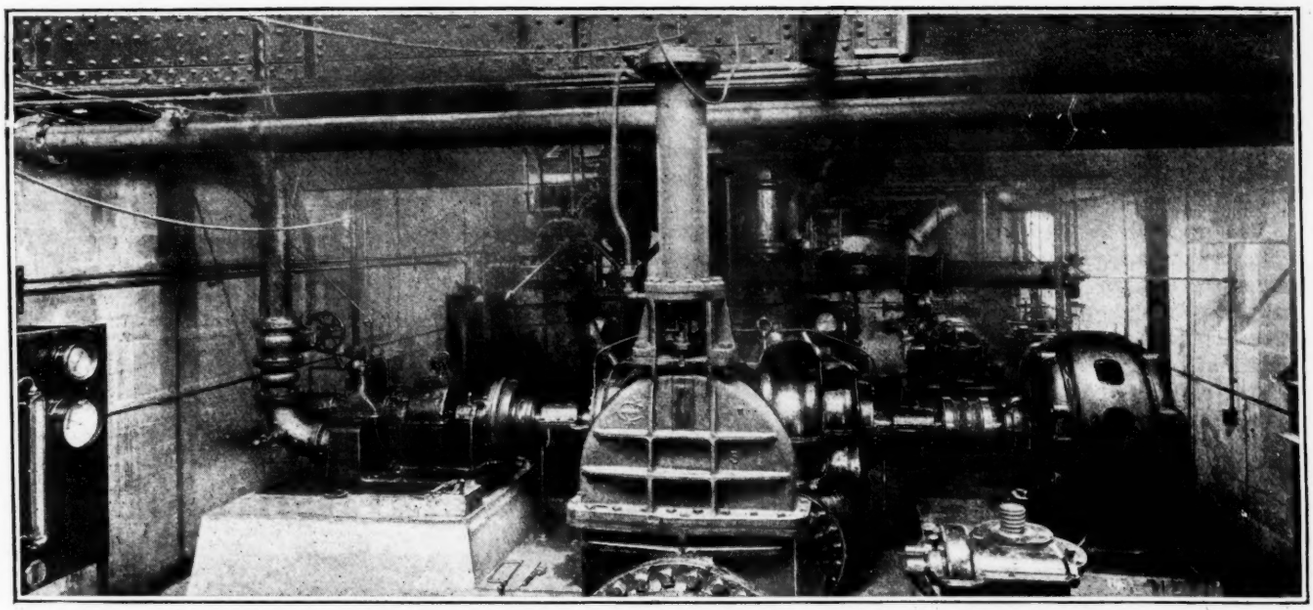


Fig. 2—Circulating pump with both motor and turbine drive. Condenser instrument board at left

are farthest apart. By this means accurate readings are obtained during normal operation. The scale divisions on the inner portion of the chart are sufficiently large to show abnormal conditions should the vacuum fall. A portion of this board appears in Fig. 2.

A complete equipment of portable testing instruments is on hand for further checking of the operation. Electrical indicating instruments in the control room are of the usual variety. The generator voltage regulator, however, operates the field rheostat instead of employing the more usual vibrating-type solenoids. The regulator therefore varies the main generator field current

BOILER ROOM, TURBINE ROOM AND CONDENSER PIT INSTRUMENTS AND CONTROL

ON EACH BOILER CONTROL BOARD

Drum steam pressure	Ind. pressure gage	Ashcroft
Feed pressure before regulator	Ind. pressure gage	Ashcroft
Steam output from boiler, 2 outlets	Rec. boiler meter	Bailey
Air flow through setting		
Blast, air duct and each stoker compartment	8-pointer draft gage	Bailey
Draft, furnace, uptake, fan suction	4-pointer draft gage	Bailey
Stoker speed	Pneumatic tachometer	Bailey
Superheated steam temperature	1-pen rec. thermometer	Foxboro
Economizer gas inlet and outlet temperatures	2-pen rec. thermometer	Foxboro
Economizer water inlet and outlet temperatures	2-pen rec. thermometer	Foxboro
Induced-draft fan motor current, 60 hp.	Ind. ammeter	Westinghouse
Induced-draft fan motor current, 250 hp.	Ind. ammeter	Westinghouse
Induced-draft fan controller position	Elec. pos. indicator	Westinghouse
Forced-draft fan controller position	Elec. pos. indicator	Westinghouse
Induced-draft fan hand control	Push-button box	Westinghouse
Forced-draft fan hand control	Push-button box	Westinghouse
Stoker-motor control	Drum controller	Westinghouse
Clinker-grinder motor controls	2 primary switches	Westinghouse
	2 hand starters	Westinghouse
Master fan control (1 for both boilers)	Push-button box	Westinghouse

ON FEED-PUMP GAGE BOARD

Steam pressure at turbine bleeder	Ind. pres-vac. gage	Ashcroft
Steam pressure in boiler-feed open heater	Ind. pres-vac. gage	Ashcroft
Temperature deaerator separator water inlet and outlet	2-pen rec. thermometer	Foxboro
Vacuum deaerator separator	Rec. vacuum gage	Foxboro
Vacuum in deaerator separator	Mercury column	Tycos
Pressure at feed-pump suctions	Ind. pres.-vac. gage	Ashcroft
Pressure at each feed-pump discharge	2 ind. pressure gages	Ashcroft
Feed-pump delivery	Flow indicator	Bailey
Total boiler feed	Rec. venturi meter	B. I. Foundry
Exhaust-steam flow to atmosphere	Rec. steam-flow meter	Bailey

ON EVAPORATOR EQUIPMENT

Steam pressure in each evaporator manifold	2 ind. pressure gages	Ashcroft
Vapor pressure in each evaporator dome	2 ind. pres.-vac. gages	Ashcroft
Temperature of saturated steam supply	Ind. thermometer	Tycos
Temperature at evap. feed pump discharge	Ind. thermometer	Tycos
Pressure at evap. feed pump discharge	Ind. pressure gage	Ashcroft

ON DEAERATOR EQUIPMENT

Condensate temper., extrac. heater inlet	Ind. thermometer	Tycos
Condensate temper., extrac. heater outlet	Ind. thermometer	Tycos

ON GAGE BOARD NEAR MAIN TURBINE

Generator load	Ind. wattmeter	Westinghouse
Generator phase position	Synchronism ind.	Westinghouse
Superheated steam pressure and temper.	Pres. & temp. recorder	Foxboro
Generator air inlet and outlet temper.	2-pen rec. thermometer	Foxboro

ON MAIN TURBINE

Steam pressure at throttle	Ind. pressure gage	Ashcroft
Steam pressure at turbine inlet	Ind. pressure gage	Ashcroft
Pressure of gland water	Ind. pressure gage	Ashcroft
Pressure of bearing oil	Ind. pressure gage	Ashcroft
Pressure at oil-cooler water inlet	Ind. pressure gage	Ashcroft
Turbine speed	Vibration tachometer	Westinghouse
Turbine vacuum	Mercury column	Tycos
Temperature oil to bearings	Ind. thermometers	Tycos
Temperature return oil from bearings	3 ind. thermometers	Tycos

ON CONDENSER GAGE BOARD

Condenser vacuum	Ind. vacuum gage	Ashcroft
Temperature exhaust, condensate and circulating water outlet	3-pen rec. thermometer	Foxboro
Water level in service water tank	Ind. liq. level gage	Foxboro

ON CONDENSER PUMPS AND CONNECTIONS

Temperature circulating-water inlet	Ind. thermometer	Tycos
Temperature circulating-water outlet	Ind. thermometer	Tycos
Pressure at top of condenser tail pipe	Ind. pres.-vac. gage	Ashcroft
Pressure at circ. water-pump suction	2 ind. pres.-vac. gages	Ashcroft
Pressure at circ. water-pump discharge	2 ind. pressure gages	Ashcroft
Pressure at condensate pump discharge	2 ind. pressure gages	Ashcroft
Temperature of condensate pump discharge	Ind. thermometer	Tycos
Pressure at hydraulic air-pump suction	Ind. pres.-vac. gage	Ashcroft
Pressure steam supply to air ejectors, before and after reducing valve	2 ind. pressure gages	Ashcroft
Vacuum in ejector intercondenser	Ind. vacuum gage	Ashcroft

ON MISCELLANEOUS PUMPS

Pressure at overflow-pump discharge	Ind. pressure gage	Ashcroft
Pressure at makeup-pump discharge	Ind. pressure gage	Ashcroft
Pressure at sump-pump discharge	Ind. pressure gage	Ashcroft
Pressure at service-pump discharges	2 Ind. pressure gages	Ashcroft
Pressure of air-compressor discharge	Ind. pressure gage	Ashcroft
Pressure in air-compressor receiver	Ind. pressure gage	Ashcroft
Temperature of jacket-water outlet	Ind. thermometer	Tycos

MISCELLANEOUS INSTRUMENTS

Pressure in main steam header	Ind. master gage	Ashton
Atmospheric pressure	Mercurial barometer	Tycos
Level in distilled-water tank	Float and rod	
Level in surge tank	Float and chain	

PORTABLE AND TEST INSTRUMENTS

Orsat gas-analysis apparatus	Hays
Winkler oxygen-test apparatus	Elliott
Centrifugal hand tachometer	Standeo
Dead-weight gage tester	Crosby
Test-pressure gages	Ashcroft
Cylindrical test thermometers	Green
Voltmeter, a.c.-d.c.	Westinghouse
Ammeter, a.c.	Westinghouse
Battery voltmeter	Westinghouse
Cadmium battery test electrode	Westinghouse
Storage battery hydrometer	E.S.B. Co.
Recording chart averaging instrument	Bristol
Inclined-tube draft gage	Ellison

only, permitting the maintenance of constant voltage on the excitation bus.

A feature of the electrical layout is that the 11,000-volt generators will not be paralleled at generator voltage. Transformers are interposed between generators and buses, their reactance, with that of the generators, limiting short-circuit currents and mechanical stresses to practical values.

The general design of this station is based on using a main power transformer of the same relative capacity as the generator and providing an intermediate connection for stepping down to station auxiliary service. The latter is arranged to be connected with the auxiliary buses of other units in case of emergency. Each generator will be directly connected to its own transformer bank in which the voltage is stepped up to 33,000 or 66,000 volts, present operation being 33,000 volts. Future transformer banks will be connected in parallel on the high-voltage side.

Three-phase power for the station auxiliary service is furnished by a 1,500-kva. bank of transformers which steps down the 11,000-volt generator voltage to 2,200. Auxiliaries are driven by alternating-current motors of both 2,200 and 440 volts as well as those of 230 volts, direct current. In general, alternating-current motors of 50 hp. and above are wound for 2,200 and smaller motors for 440 volts, all being of the squirrel-cage type except the fan and crane motors. In order to give satisfactory speed control, 230-volt direct-current motors are provided for the stoker and clinker-grinder drives. These motors are supplied from a 30-kw. motor-generator set.

Thermal Versus Commercial Efficiency*

By W. G. DIMAN

MANY of the earlier industries were located upon streams in order to take advantage of water power, but most of the water powers within reasonable distance in New England which have been so used have been outgrown and in some of these places there is a preponderance of steam power. New centers of manufacturing have grown up, some on tidewater where cheap fuel and low rates for transportation can be obtained. With the advent of electric power and its increased use in industries, the water powers that have been remote have become useful and have permitted industries to be placed in more advantageous centers.

This has brought about the gradual interconnection of electric lines and the attention of the public to the idea of a superpower program; as a result the discussion of this subject is no longer confined to engineers, but has become of general interest among the laymen. Unfortunately, this discussion is frequently based on distorted ideas and even among engineers, perverse thinking concerning power supply and cost is by no means conspicuous by its absence.

There is going on in the field of power development, public-utility service and industrial plants today, design work that sometimes prevents the most economical results from a financial viewpoint. This is due in some instances to ignorance of what is involved in the way of capital outlay and returns on the investment, and in some cases to a desire to install a modern plant to gain supposedly more economical results. It is quite easy to design and erect a plant or install new apparatus, but the principal object is to have such designs show economy and a financial return.

Before any changes are made in a plant, it must be known how to operate the existing equipment at the lowest possible cost for the required service and also how the present costs can be reduced or services be improved by the addition of new equipment or alterations in the present arrangement of the plant. It is not so much a question of thermal efficiency, increased ratings, reduced steam or power consumption, as it is a question of actual reduction in the total operating costs after all charges are paid. Money costs money just as truly as does coal, labor or any other of the power-plant supplies. The cost of new money must, therefore, be figured in the recommendations for improvements. It is often found that supposed improvements have actually increased the total costs when fixed charges, maintenance and other items have been added to the operating charges. The final test is, how much will it reduce the total costs and what will be the return on the investment?

There is a tendency on the part of some industrial executives to look with disfavor on revamping an old plant. What they desire is a new one with some new boilers and all the modern apparatus that goes with them. But there are many old plants that can be made into efficient properties with far less outlay than a new plant would cost and in the end will produce steam just as cheaply. Sometimes, upon making a survey of an old plant, certain consulting engineers will make a report calling for a new plant and abandoning the old one. Engineering questions of importance are sometimes decided without even getting the opinion of men long trained in their specific work. All the facts in any case should be brought out, and no design or recommendations should be made to meet any other condition than that of furnishing the engineering proposition for the particular case. Almost anyone can go into an average plant and make suggestions that will give economy in operation, but there is always the question whether the improvements will show a net gain in the long run when everything is taken into consideration. The real task is to differentiate between improvements that apparently show a gain but do not, and those that do.

There has been a great need of some standard method of stating efficiencies on a dollar-and-cents basis. This, to my mind, is the whole basis of efficiency; in other words, what are you going to obtain on the return for your investment? The grading of boiler performances on the thermal-efficiency basis or over-all plant performances on the basis of B.t.u. consumed per kilowatt-hour is common. While those making the comparisons would admit that such figures, by themselves, prove nothing as to the relative economic performance of power plants, the mere fact that such comparisons are frequently made without divulging cost figures inevitably tends to create false impressions.

If the bald statement is made that one plant consumes 20,000 B.t.u. per kilowatt-hour, while another

*Extract of paper read before the National Association of Stationary Engineers, Manchester, N. H.

takes 18,000 B.t.u., the average person is likely to conclude that the second represents better engineering practice. Such a conclusion may be entirely unjustified. If the engineer's attention is to be directed to commercial efficiency rather than mere thermal efficiencies, he must be given an expression for the former as simple and definite as those he possesses for the latter, and the efficiency that brings out the actual cost of producing a kilowatt, when all costs are taken into account, is the only efficiency that should be considered.

It is only a few years ago that the steam turbine began to make rapid strides as a prime mover, and with practically each succeeding important installation reduction in water rates have been recorded. Other power-plant equipment followed the progress of the turbine. Steam pressures have increased as well as improvements in condenser design which have succeeded in bringing down the water rates.

Low Water Rates Not Always Profitable

However, the experience of some of these plants and equipment made it very clear it was one thing to design and build a power plant and an entirely different thing to operate it. It was found that these low water rates not only required expensive construction, but also ran the maintenance charges up to a high figure compared with plants operating at more conservative ratings. A careful analysis has shown that lowest water rates and highest boiler efficiency do not always mean lowest cost at the feeders and do not always mean high reliability in plant operation.

Power cost is a relatively small item in most industries. It seldom reaches over 10 per cent in the cost of the finished product, and many executives have on this account looked upon their power plants as unimportant so far as presenting opportunities for reducing costs.

In numbers of plants the only available of the power costs are the paid invoices in the general offices covering coal and purchases of other material to produce the power. The major item of expense is fuel; and this is usually purchased without reference to its qualities except the price per ton. It is dumped into the boiler room and the firemen presented with shovels and told to burn it. What this coal produces in steam and converts into power often appears to be of little value because nothing is measured or weighed, not even the coal itself, except in the car as it comes in. What other line of raw material is put through in such a manner? The reason for this is plain; coal has, until recently, been relatively cheap, and heat and power have been measured in terms of costs of the finished product or not measured at all; and when measured this way, the product of the power plant has presented rather an insignificant figure.

A large number of people believe that the real cure for our fuel problem lies in the more economical generation of power. The large central power plants are pointed to as being great economic factors in decreasing coal consumption. If all the small power plants are closed down and their power supplied from the central station, according to some writers, much of the coal now burned in the multitude of small plants would be saved.

This agitation has led to a lot of erroneous notions by the man on the street, who has a general idea that if all the water powers are developed we will have immediately cheap power in abundance and thereby save enormous amounts of coal. It remains to be said, however, that proper engineering discrimination must be used in this water-power development as many such installations will not prove as attractive from a financial viewpoint as they appear. In many manufacturing plants there is some use for low-pressure steam. The use of exhaust steam and overflow water from the condenser tends to reduce the net cost of steam power and therefore to reduce the value of water power for this particular use.

In connection with the use of byproduct heat it might be pointed out what strides are being made toward increasing the thermal efficiency of the large central condensing steam plant and how little has been done or accomplished toward utilizing the byproduct heat. The efforts to raise the efficiency in the former have accomplished probably 10 per cent, while the latter will bring an over-all efficiency far above anything that can ever be accomplished in the former. Why not give more study and effort toward taking advantage of the latter condition? There are many opportunities along this line—that is, the use of byproduct heat—and when as much effort is put into this as is used in increasing the thermal efficiency of condensing steam plants, perhaps developments may come that have not even been thought of. It must be remembered that important as power and electricity supplies are, heat supplies are in fact more fundamentally necessary. The present system of fuel utilization is primitive when compared with electrical utility development. The time will surely come when greater thought will be given toward the utilization of heat. This must be a part of the problem of power and electricity supply.

Using Exhaust Steam

The use of exhaust steam for heating work has been sadly neglected. To those who are in the textile business, and I imagine this fact also exists in other lines, there has been little improvement in the method of using manufacturing steam and drying for a number of years. It has been difficult in many cases even to reduce steam pressures for manufacturing processes, and in some instances this has been accomplished only through a more or less underhanded method of wrongly setting the steam gage. There should be more coordination and all should work together to accomplish the same end; that is, saving in fuel and a lower manufacturing cost. Just think what could have been accomplished in the last twenty years if the same thought and energy had been put into this line as has been put into other lines! Exhaust steam can be used for a great variety of purposes, particularly for all sorts of drying, both direct and indirect, when the object is only to remove moisture. Water can be heated for all domestic purposes for use in tanneries, bleacheries, all textile plants, dyehouses, and scores of other plants. Water may be heated slowly and stored during the night to be available for the rush start in the morning. It is a great mistake to heat buildings with live steam when there is any exhaust steam available. It is frequently possible to use all the waste steam in the winter for these purposes and run condensing in the summer.

The solution of our troubles does not lie with superpower, nor will the isolated plant be the best solution in all cases; rather, a combination of the two with proper consideration given to both power and heating, as well as the use of steam for industrial purposes. This will be the intelligent answer.

Bureau of Standards Reports Steady Progress with Steam Research

THROUGH the courtesy of the Bureau of Standards information has been made available on the present status of the steam-research work at that institution.

It will be recalled that four articles, published in the Aug. 5, 12, 19 and 26 issues of *Power*, described the general purposes and some of the details of the steam research going on simultaneously at the Bureau of Standards, Harvard and the Massachusetts Institute of Technology. These articles were published to give to power-plant engineers and other workers in the power field a picture of an important and delicate piece of scientific research work, the results of which will greatly benefit their profession.

The following remarks are based on the latest information received from the Bureau of Standards, together with that previously available.

According to the scheme of experimentation previously described the apparatus was to consist of a highly refined type of calorimeter provided with internal electrical heating. This calorimeter was to be used not only for obtaining the specific heat of water in energy units, but also for determining the latent heat of steam and various derived quantities.

Further Developments in Calorimeter Design

The accompanying drawing shows the present state of the design, which is substantially like that shown in the Aug. 12 issue, but with the addition of certain measuring devices, accessories, etc., which at that time had been planned but not designed.

The apparatus as shown consists of a central calorimeter shell provided with electric heating and stirring devices, with arrangements for the transfer of vapor or liquid to or from the calorimeter. Provision is made for the determination of weights, temperatures and pressures.

It will be noted from the drawing that extraordinary precautions have been taken to prevent heat leakage between the calorimeter and other bodies. The only supports of the calorimeter are thin tubes of silver-palladium alloy at the top and bottom. This alloy combines a fairly low thermal conductivity with chemical resistance to the action of hot water and steam.

By surrounding the calorimeter with an envelope shell maintained at the same temperature, with a vacuum in the space between, the transfer of heat is practically eliminated. The temperature of the envelope control bath is regulated by cooling coils and electric heating coils, then by a layer of lagging and finally by a cooling coil outside the lagging.

External condensers and containers are provided to catch and weigh any liquid or vapor that may be removed during the experiments.

The apparatus is capable of determining the heat content of saturated liquid water and saturated water vapor, the heat of vaporization, the specific heat and entropy of saturated liquid and vapor, etc., in addition to giving a check on vapor pressures and specific volumes. The range for which the research is being planned is from 32 to 572 deg. F. and from 0 to 1,224 lb. per sq.in. While these are the chief results sought at this institution, the apparatus is also suitable for measuring the heat content of superheated steam.

In work of this sort the big job is the development of suitable apparatus. When this has once been accomplished, the actual work of obtaining the desired data is relatively simple. Each detail has to be worked over with utmost care to insure suitable design, materials and construction.

It has required some effort to find available materials from which to build, with confidence in the continuous and reliable operation of the apparatus, under requirements and conditions outside of the range of well-known properties of customary materials and types of construction.

Precious Metals Extensively Employed

To resist the action of the hot water, pure silver has been used where possible. Where greater mechanical strength was necessary, an alloy of silver with 30 per cent gold has been chosen, while an alloy of silver and palladium was used where botn strength and low thermal conductivity were required—as in the supporting tubes.

For the tiny ball bearings to carry the pump impeller shaft, a special alloy of iridium, osmium, etc., has been obtained. Nearly $1,500 has been expended in obtaining special costly materials of construction needed to insure the necessary refinement of experimental work.

The development work has involved the learning of new methods of working metal. In this respect everything has so far gone along as well as could be hoped for.

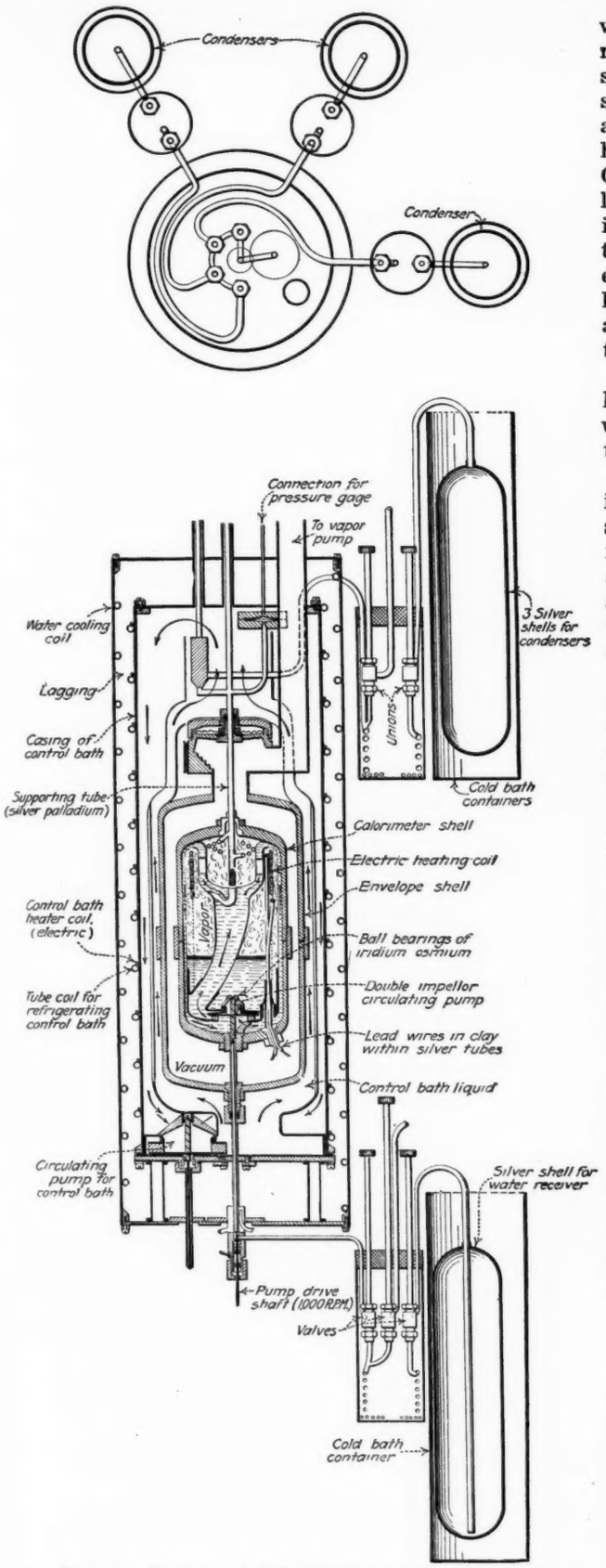
A considerable part of the calorimeter has been actually constructed of the final materials and subjected to tests for strength, tightness and assembly. The working out of details has proceeded as rapidly as the available shop facilities would permit.

Three Sets of Experiments Planned

When the apparatus is completed, the first series of experiments will determine the heat content and the specific heat of a saturated liquid. After this series a change in the connections will be made for the second series of experiments, which will determine the properties of the saturated vapor, including latent heat of vaporization, specific heat, heat content, entropy and specific volume.

If it is deemed advisable to continue further after these experiments are completed, a third series will be made to determine the heat content of the superheated vapor. It can be shown that this result may be obtained if the vapor is withdrawn from the calorimeter after being throttled to a lower pressure and then reheated back to the saturation temperature of the free steam in the calorimeter. A simple type of throttle to permit this operation has been devised, and this will be installed in the instrument.

It is too early to predict what accuracy may be expected from these throttling experiments, or with



Present design of calorimeter and accessories

By means of a stirring pump of extraordinarily delicate construction the water in the calorimeter shell is continually circulated, part of it being bypassed over a gauze-encased electric heating coil through which a measured quantity of energy is supplied. Every precaution is taken to reduce heat leakage to an absolute minimum. All surfaces exposed to hot water or steam are constructed of (or coated with) precious metals to prevent corrosion.

what nicety the desired points in the superheat field may be approached. But, at the worst, the accuracy should be about the same as for the heat content at saturation. This method would have two distinct advantages over the throttling method which has hitherto been used for studying superheated vapor. One advantage is that the troublesome element of heat leakage can be kept definitely under control. The other is that the region immediately in the vicinity of saturation can be actually covered by experiment instead of by extrapolation from a more remote part of the superheat field. While the desirability of this method of attack has not yet been proved, its possibilities seem too good to be dismissed without a test.

Without attempting to describe the many things that have been done in the last few months, a few examples will show the nature of the problems encountered and the methods of solving them.

The parts for the centrifugal pump casing to be installed in the calorimeter shell have been of pure silver. This has involved making dies and punches, rolling sheet silver, forming the desired shapes, spinning certain parts, making and drawing tubes and autogenous welding both by the oxyhydrogen flame and the electric arc, in addition to the ordinary machining operations.

The calorimeter stirring pump, as explained in the previous article, has a double impeller, a "high"-head section to circulate water over the evaporating coil and a "low"-head section for a simple stirring of the liquid within the calorimeter.

Miniature ball bearings have been developed for the runner of the pump, with balls $\frac{3}{64}$ in. in diameter and the entire bearing only $\frac{3}{16}$ in. over-all diameter. These bearings have been worked out and tested as to running quality and resistance to corrosion, first in stainless steel and then in stellite, both materials proving unreliable and showing destructive corrosion under the combined influence of steam, air and rolling wear. The material finally adopted, as previously stated, was an osmium-iridium alloy.

Heating elements have been made of resistance wire with gold leads embedded in clay in a sheath of pure silver tubing suitable to install within the calorimeter as heater and evaporator.

Two of these elements are completed. Special thermocouple wire has been obtained and tested for temperature measurement. The details of the design have been studied for the purpose of simplifying construction and adapting it to the materials and working processes available.

Metallurgically, power plants will probably pass through, in their development, substantially the same periods that the automotive industry has. The automobile demanded exacting requirements. The metallurgical art for power plants is still backward, although it is true that it has made tremendous strides in recent years. When the day comes when the power-plant industry has technical metallurgists of the same caliber and stamp as are now found in the automotive industry, and when these men have adequate facilities for their work, then we can confidently look forward to real progress in the procurement of suitable materials for power-plant needs.—*A. E. White in Mechanical Engineering.*

Pressures and Temperatures in the Refrigerating Plant

By G. Grow

The influence of suction and discharge pressures and temperatures in the performance of a refrigerating plant is too little understood by many engineers. Frequently, a plant is found where the cost of operation is high by reason of improper pressures, yet both engineer and manager go along, quite satisfied with an operating cost that could be halved by slight alteration in operating procedure. That it is desirable to carry as high a suction pressure as possible is a refrigerating axiom, but how many recognize the truth of the corollary that the suction gas should reach the compressor with no superheat? In addition too many strive to keep down the head pressure while disregarding the suction pressure.

The influence of the suction pressure on the power required by the compressor is illustrated in Fig. 2. Here, with a 13-lb. gage suction pressure and a discharge of 120-lb. gage, the area of the indicator diagram *ABCD* is proportioned to the work required to compress and discharge the cylinder charge of gas. In the event the suction is raised to 18-lb. gage, the work diagram becomes *EGCF*. The reduction in the diagram area is *AEFD*, but there is an increase of the area *AEGB*, larger than *AEFD*. In other words the higher suction has actually increased the power required by the compressor when running at a stated speed. It is this fact that causes some to doubt the advisability of a high suction. The truth is that the weight of the gas taken in at 18-lb. gage pressure per cubic foot of cylinder volume is greater than with 13 lb. pressure, the ratio being approximately 1.15; that is, 15 per cent more ammonia is handled at the high suction pressure, while the increase in work per stroke is approximately 10 per cent. It follows that while the work per stroke increases, the work per ton of refrigeration decreases with an increase in suction pressure.

The influence of superheat in the suction is often ignored. For example, at 13 lb. suction the ammonia vapor should reach the compressor at a temperature of 2.7 deg. F. If by poorly insulated suction lines the temperature at the compressor rises to +15 deg. F., each pound of ammonia handled increases in volume 5 per cent and the power required is increased over 10 per cent per pound of ammonia handled. The absence of superheat at the suction is of more importance than is a few pounds increase in suction pressure.

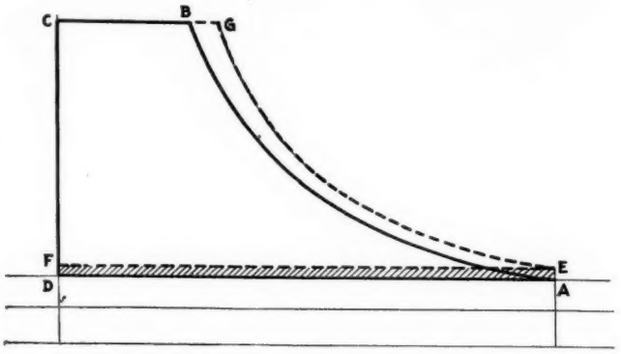


Fig. 2—Higher suction pressure increases work per stroke

The discharge pressure is dependent upon the temperature of the cooling water. If no foreign gases exist, the pressure within the condenser should be such that the boiling temperature at this pressure will be about 8 deg. higher than the cooling-water temperature. For example, if the water has a temperature of 70 deg. F., the condenser pressure should be approximately

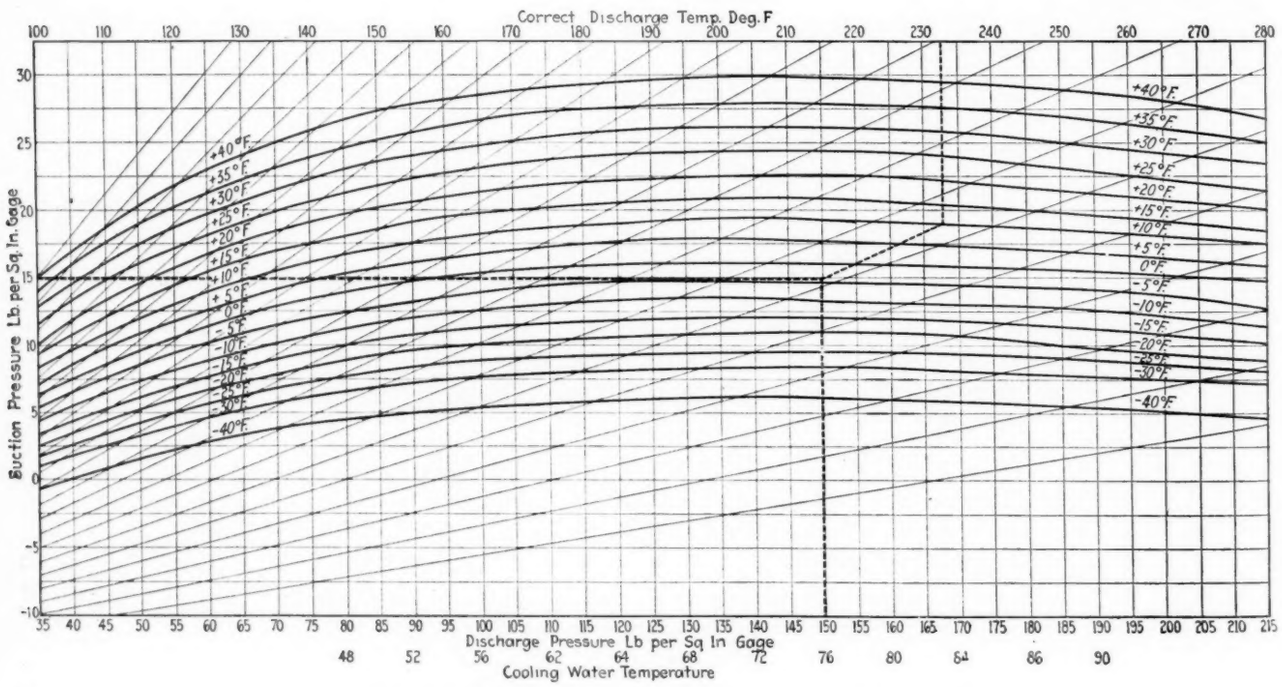


Fig. 1—Determining proper discharge pressures and temperatures

135-lb. gage. This existing discharge pressure largely determines the discharge temperature, for in compressing the ammonia to the discharge pressure the temperature increases in accordance with the ratio of the discharge and suction pressures and is also dependent upon the initial or suction temperature. With a low suction temperature the discharge temperature will be less than with a high suction temperature, the pressure ratios remaining constant.

In the chart in Fig. 1 are given the condenser pressures that should exist for a given cooling-water temperature; as example, for a water temperature of 70 deg. a pressure of 135-lb. gage is the mark to shoot at. To use the chart, in line with the cooling-water temperature at the bottom will be read the desirable discharge pressure; move vertically from this point until intersection is made with a horizontal line from the suction pressure carried. Now follow up the diagonal line from this intersection until the pencil strikes the heavy curved line corresponding to the suction temperature. By moving vertically from this point, the correct discharge temperature will be read at the top. If the thermometer shows a higher reading than that given in the chart, it may be safely assumed that there is cylinder superheat due to valve or piston leakage. If the temperature is much below the chart value, the suction is probably carrying liquid, and adjustments should be accordingly.

Increased Efficiency Through Changes in Boiler Baffling

By H. E. OSGOOD

UP-TO-DATE management is becoming keenly alert to the many savings possible through waste prevention and recovery. An investigation of the steam plant will often reveal possibilities of savings that customary practice has overlooked.

In many of our industrial plants there are local conditions that have established a routine system of operation that has become accepted as the best operation possible with the existing equipment. This is most likely to be the case when the costs are looked upon as reasonably good and a general feeling of satisfaction exists.

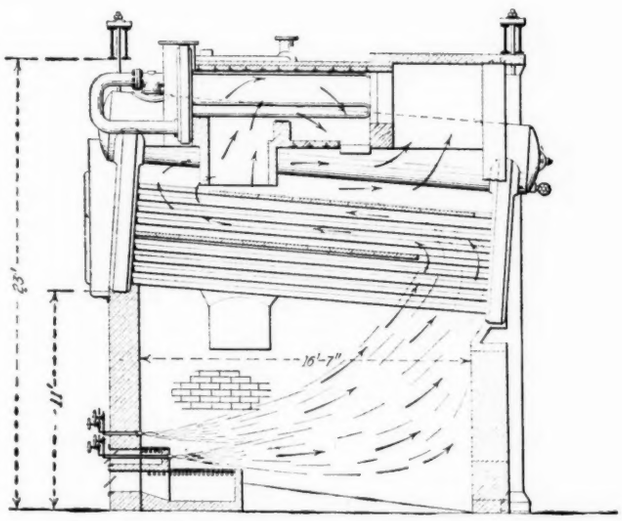


Fig. 1—Baffling short-circuited tube gases

Uncertainty of results is frequently the deterrent factor in making changes, especially when unsupported by sufficient knowledge and data to enable a definite prediction of improvement to be made.

The question of what constitutes proper baffling for any given condition is one that deserves study. Improvement is not a matter of guesswork, but may be definitely worked out if the controlling factors are accurately established. Proper equipment is necessary to obtain data and check meters ordinarily used to observe and record operation. Test information is needed and is the proper basis for intelligent deductions, supplemented by additional information such as furnace and pass temperatures, draft losses, kind of fuel and construction features of boiler.

The influence exerted by the baffling of a boiler on its efficient operation is illustrated in the following description of changes made in a well-known type of water-tube boiler fired with oil.

The boiler selected for improvement was horizontally baffled with a single pass, and had 6,000 sq.ft. of heating surface. An average evaporation of 4.5 lb. of water per sq.ft. of heating surface per hour at 140 lb. pressure and 40 deg. superheat was maintained. The setting was constructed especially for oil firing and represents good practice for ordinary ratings. Originally, the boiler had a two-pass baffling and was equipped with an underfeed stoker, but because of unsatisfactory operation the bottom baffle was removed. A sketch of the boiler when oil fired is shown in Fig. 1, which indi-

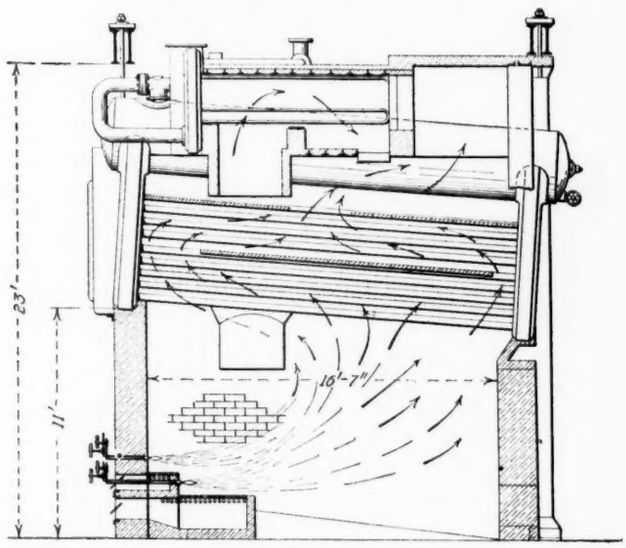


Fig. 2—Baffling after alteration

cates the travel of the products of combustion. The need of baffle revision is apparent without further study since a part of the tubes received little heat.

The burner equipment consists of six steam-atomizing, inside-mixing type burners, set three in a tier and utilizing 2 per cent of the steam produced. The velocity of discharge of the fuel jet, as figured for operating conditions, with 20 deg. Baumé oil at 155 deg. F. temperature, was 1,420 ft. per sec. No allowance was made

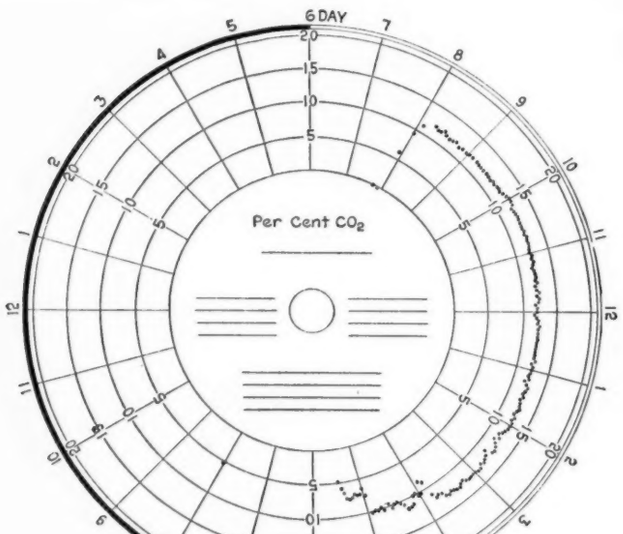


Fig. 3—CO_2 obtained with original baffling

for the vaporization of any portion of the fuel oil in the velocity determination, atomization alone being considered as the principal action in the mixing chamber of the burner. The energy of the jet produces a long flame, localizing the heat at the rear end of the furnace.

Before the changes were made, this condition was augmented by the action of the draft. With the rearranged baffles, Fig. 2, the flame velocity is noticeably absorbed at two-thirds the furnace depth, deflection of the burning gases being observed at one-half the furnace depth.

The operation before the change was never up to expectations. Although attempts had been made to improve the efficiency, operation had settled down to the following:

Average rating, per cent	150
CO_2, per cent	12½
CO	none
Excess air, per cent	20-25
Superheat, deg. F	40
Flue-gas temperature, deg. F	620
Efficiency, per cent	74

The baffles were located on the ninth and sixteenth, or top, rows of tubes, and an inspection of Fig. 1 shows that the front section of the lower ninth rows received but a fraction of the heat of the burning fuel, for the flame was driven to the rear end by the velocity of discharge from the burners and by the suction due to draft. No transmission of heat by convection existed in the front section, and little if any radiant action existed above the second row of tubes. The temperature conditions among the tubes at this section of the boiler was not obtainable, but must have been comparatively low. This condition was evident in the removal of scale, a heavy deposit always existing near the rear end.

In order to equalize the flow of gases, the rear pass in the lower baffle was reduced to one foot, and a three-foot opening was provided at the front end. The top baffle was opened at the middle and reduced from four to three feet. The arrangement has resulted in dividing the gases, and a much more even distribution of the heat throughout the lower bank of tubes is obtained.

The results demonstrate the correctness of the deductions reached in the analysis of the original conditions. The operating characteristics are now:

Average rating, per cent	150
CO_2, per cent	14
CO	none
Excess air, per cent	15
Flue-gas temperature, deg. F	540
Superheat, deg. F	42
Efficiency, per cent	77.8

CO_2 records, Figs. 3 and 4, show graphically the improvement effected.

The plant contains 30,000 sq.ft. of boiler-heating surface and changes are being made in all the boilers. The saving in oil for August, with two units operating under the new baffle arrangement as against the consumption for July per twenty-five million pounds of water evaporated, is 9,250 gal., which at 4c. per gal. represents $370.

During the month the fuel was changed from a 20-deg. to a 16-deg. Baumé oil and the B.t.u. content fell from 18,875 to 18,290, which necessitated an increase in oil

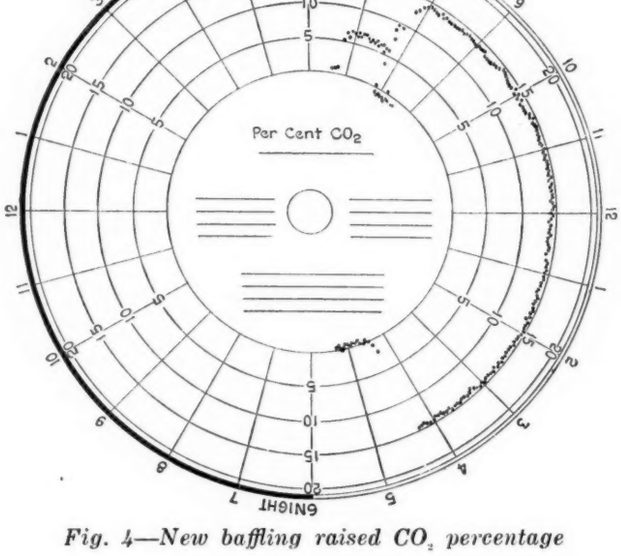
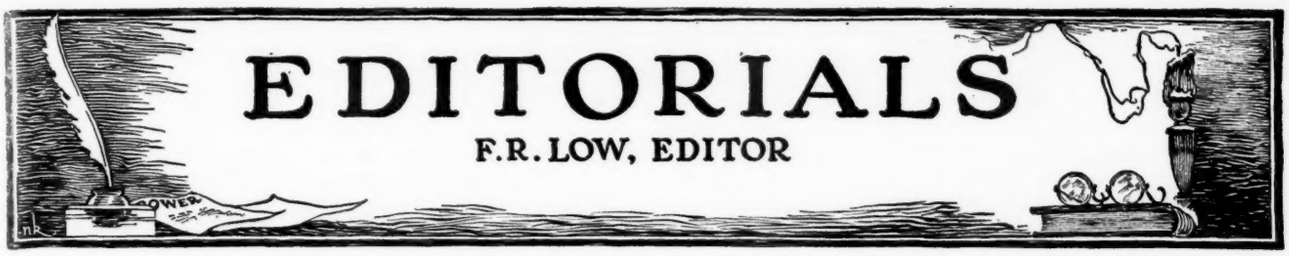


Fig. 4—New baffling raised CO_2 percentage

temperature as fed, from 140 to 155 deg. F. No change in the operating conditions or personnel was attempted, the change in baffling only being accountable for the result.

Northern Florida has put artesian wells to work and produced hydro-electric plants that apparently defy the laws of gravity. The water, coming from a higher source under the ground, rushes out with enough force to operate a turbine, which in turn runs a generator.—*P. G. & E. Progress.*



As Interests May Appear

IN THE development of the power sites on a river system a number of other interests, such as irrigation, municipal water supply and navigation, may have to be considered in the same development with power. Navigation and power are very much in the forefront in the development of the St. Lawrence River and the Great Lakes waterway. In addition to the interests of power and navigation in this waterway, Chicago has a claim for water for the city's sewage system. Furthermore, the project is much involved in state, national and international politics.

This project comprises an inland deep waterway over twenty-three hundred miles long and a possible development of approximately ten million horsepower. On account of restrictions placed on the water in the Niagara River, the total power that can be developed will be considerably below the possible ten million horsepower. However, the St. Lawrence alone involves four million horsepower, all of which can be developed at the opportune time. It is in this section of the proposed deep waterway to the sea that navigation and power are more closely involved than in any other part of the route and will require a possible capital expenditure greater than that for the Panama Canal.

One of the many questions that have arisen concerning this project is, What interests are to stand the cost of the proposed improvement? Is it to be the power development or navigation or both? The most reasonable answer would apparently be that both should share the cost in so far as interests may appear. However, it has been proposed that the water power should subsidize navigation, and eventually pay the cost of the development.

In this proposition the first question that must be answered is, Will the cost at which the water power can be produced stand the additional burden of navigation improvements and still be able to compete with power from other sources? If this cannot be done, there can be no power development under such conditions and there cannot be any navigation improvements. The distances to which this power must be transmitted to find a market at the present time will make its cost delivered such as to leave some doubt of its ability to compete with power generated locally in large steam plants. On the other hand, even if the water power can be developed at a cost that would allow of its carrying the whole cost, such a proposition does not seem just. If anything, the more equitable arrangement would be that navigation could afford to subsidize the power development on account of the benefits it will derive from the large industrial centers that will eventually grow up in the vicinity of such large power developments.

The benefits occurring from a three thousand mile inland waterway that can be developed to handle some two hundred million tons of freight per year will be very great and extend far beyond the waterway itself. This is also true of millions of horsepower of cheap power. Although it is commercially possible to transmit this power only about three hundred miles, the economic value of such resources reaches far beyond. Niagara Falls is an outstanding example of this, as the products of electric furnaces supplied by this power have in many cases practically revolutionized certain industries and made others possible. In fact, instead of reaching only to the limits of commercial electrical transmission, Niagara power reaches into practically every home in the country in one form or another. Therefore, why should water power subsidize navigation? Both possess great economic values and both should be encouraged. So in the St. Lawrence development, when the time comes to go ahead with the work, it should be on an equitable basis that will render a maximum of navigation and power at a minimum cost to each.

The Golden Age of Research

SCIENCE, which for more than a century has been the guiding star of the intelligent minority, has recently made enormous gains in prestige with the average citizen. The every-day application of the term "science" to such fields as boxing and baseball is an intended compliment. Radio, with its universal and spectacular appeal to all mankind, is chalked up as a "home run" for science. It is not at all unlikely that the indirect value of radio as a living advertisement for science in general, resulting in greater support and activity in all scientific fields, will in the long run exceed its direct contributions, great as these will undoubtedly be.

Of course, the victory of science is still incomplete. Even in this enlightened age it would be hard to convince the average citizen that the health, wealth or happiness of himself or his children will in any way be enhanced by the recent investigation on "the effect of light upon the migration of pigment in the retina of a turtle's eye." Yet it is difficult for any student of scientific history to avoid the conclusion that any piece of genuine research, revealing new facts of nature, must eventually tie in with other work to yield practical results out of all proportion to the cost.

The chief distinction between research of the type mentioned and that (for example) into the electrical and acoustic properties of radio loud speakers, or the properties of metals at high temperatures, is that the latter promise a direct and immediate return on the investment, while the former must perhaps be looked upon as a gift to future generations.

Genuine research work of every sort should be encouraged, but it is only natural that those projects which promise the most direct return should secure the greatest support from business and the general public.

Strange as it may seem, this situation has worked to the mutual advantage of pure and applied science. In this prosperous country there is always a certain amount of wealth seeking worthy philanthropic outlets. Relieved by business of the necessity of supporting a great mass of practical research, more of this wealth flows to the universities for the support of the work in pure science.

It is plain that America has entered an era of unprecedented activity in every field of pure and applied science. In this lies the greatest hope for future happiness and prosperity. The engineer, strategically located at the point where abstract knowledge is transformed into practical results, can interpret this activity and give it valuable support.

Standardizing Allowable Pipe Strains on Steam Turbines

STANDARDIZATION has proved its merit in overwhelming fashion, and there still exists urgent need of such treatment in many fields. Standardizing the strains on turbines that must not be exceeded as resulting from steam pipes connected to them, has received some attention, and tentative lists of maximum allowable pipe thrusts, based on capacity, have been considered. Such a problem as standardizing allowable stresses, however, is of a complicated nature, and it is doubtful if a simple sweeping list of thrusts based on capacity alone, would do the subject justice.

In the first place, single-stage rigidly built units are naturally better fitted to withstand external forces of this character than those of equal capacity, but of multi-stage type and a more flexible construction due to allowance for expansive movement or to other reasons. Small units fall more nearly in a uniform class than larger, as in the latter special design brings widely different constructions into prominence. The method of determining the external force exerted is a delicate one, as this, for instance, may be produced only under full-load conditions, where separating a bolted joint and taking physical measurements would hardly be applicable. It would perhaps be more satisfactory to measure strain instead of stress; that is, check the deflection that the pipe actually produces on the throttle valve or other element. Variations of turbine construction would present a grave difficulty to standardizing on this basis.

In the third place, a pipe may simply thrust in one direction such as up, down or horizontally, etc., or it may exert a twist, or an oblique force. Measurement of stresses caused by piping is therefore essentially a difficult matter. The definition of allowable pipe strain in terms of simple thrust alone would hardly do the subject justice.

Some form of specification as a limit for external force to be exerted by piping, as based on capacity, would undoubtedly be of value for small or medium turbines whose physical characteristics can readily be classified. A possible method to simplify the defining of pipe conditions would be to specify horizontal thrust at right angles to a chosen bolted joint, together with a degree of flexibility determined by a simple test. Consideration should be given to both cold conditions and those occurring directly after carrying full load.

For large units, however, where the allowable resistance to such external forces may vary greatly with different designs, it would seem far more reasonable to allow pipe strains to be restricted according to the turbine manufacturer's ideas. From installation experience he is well qualified to judge, and the responsibility for the unit's smooth operation is a paramount incentive to utilize a conservative construction. In order that expansion forces set up in other parts of the pipe line, such as by putting in service boilers or prime movers, should not affect a unit under consideration, the line could be rigidly fixed in the vicinity of the throttle connection. Thus if a strainer, separator or elbow is rigidly mounted, to be piped to the turbine by its manufacturer and connected to the main steam supply by the purchaser, questions of responsibility may be limited to those affecting the turbine performance alone. Such piping plans are not untried, and the increasing complexity of power-plant equipment makes forethought desirable, which may be the means of avoiding inconvenience.

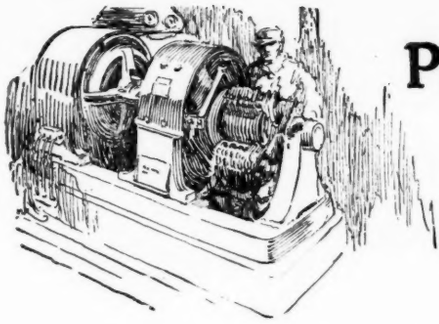
As *Power* goes to press, the newspapers announce a sailless "windship," the invention of Herr Flettner, of Berlin, Germany. While the information (November 7) so far released is delightfully vague, it appears that a mast-like revolving "cylinder" absorbs the wind's energy in an amazing fashion, each square yard of mast equaling fifteen square yards of sail. Perhaps! But when the claim is made that liners run at normal speed will save 90 per cent of their fuel and be able to cut their passenger rates 66 per cent and that a "wind" central station in Berlin will save 60 per cent of the cost of current, one must conclude that this device runs mainly on hot air.

Judging from the number of studies being made as to the possibilities attending combined central-station generating and heating plants, engineers are beginning to appreciate that all economies are not centered in the pounds of coal per kilowatt-hour. While exhaust-steam heating for a distribution system has, in general, proved unprofitable, the perfection of the bleeder turbine permits of steam distribution at the most advantageous pressure to suit local conditions. At the same time it takes advantage of a vacuum for the steam not required for heating. Several stations are now operating on this principle with apparent success, considering local conditions.

In spite of much that is being said regarding high steam pressures, an idea of what is actually being done in practice is afforded by the latest serial report of the N.E.L.A. Prime Movers' Committee. This shows that out of twenty-one central stations recently completed, only one carries a steam pressure of 400 lb. and of ten additional plants nearing completion three will have pressures of 400 lb. and over. By far the greater number of these new stations operate between 300 and 375 pounds.

For the large plant the economies of the regenerative cycle are generally accepted. To what extent its application is warranted in the small plant will depend upon the saving balanced against the fixed charges on the additional investment. It is a subject that will bear further study.

The problem of furnace maintenance with pulverized coal seems to have been met successfully in spite of the predictions of some that the cost would be excessive.



Practical Ideas *from* Practical Men

Pounding in Duplex Pumps

Pounding in duplex pumps is a trouble with which all engineers are familiar. Undoubtedly, one of the most common causes is wear on the valve gear.

Recently, one of our duplex pumps developed a bad pound. By careful adjustment of the cushioning valves the knock could be reduced, but the steam pistons would still hit the cylinder heads. After some experimenting we concluded the trouble to be due to the lost motion in the valve gear. When this had been removed and the cushioning valves adjusted, the pump operated smoothly and quietly. CHARLES FRAZER.

Cleveland, Ohio.

Preventing Cracks in Boiler Settings

A round boiler can be made cheaper than a flat one of any kind, and as long as this axiom holds good, just so long will brick settings be used, although they are always expensive, and frequently unsatisfactory, because they do not stay as built, and hence cracks develop.

There may be cases where no crack can be found in these massive settings, and it is safe to say that most cracks are unnecessary. If the following suggestions are followed, their number will be greatly reduced.

Sometimes the two side walls of a setting of a return-tubular boiler are built up to a proper height without tierods to bind them together at the top. Then a heavy arch is sprung over the top, either end of it resting on a wall. The natural result is that the side walls are forced apart and cracks appear.

In addition to the weight of the arch pressing on the side walls it is necessary to build a shallow well around the manhole on top of the boiler, which is difficult to keep tight and adds much to the inconvenience of going through the manhole to inspect the boiler. Should a leak appear in any part above the water line, it is inaccessible until after the bricks are removed. If the side walls are built up as high as the top of the boiler and the upper part of the shell is covered with asbestos 3 or 4 in. thick, it will be equally well insulated, more easily removed, and desirable from every viewpoint.

One cause of trouble with these walls is that the builder seems to have concluded that the conditions are the same as in the case of an ordinary building, and the effects of great heat are not taken into consideration. This is evidently a mistake, as buckstays should be used on the outside of the walls and tierods used to connect them above the boiler, thus preventing the walls from spreading.

When the cast-iron front of a tubular boiler is set in place, it requires bolts to hold it, and sometimes these are not more than three feet long. The mason who is doing the job is sure that they are long enough because the fronts require but little force to hold them in place. Let us follow out the process and note the result. A fire is built and heat causes the expansion of every part that it reaches. When the whole is cooled off, contraction takes place, and a minute space is left wherever there is a joint. Particles of mortar and dirt fall into these spaces, and when heat is again applied and expansion takes place, a small crack is started near the end of the bolt, and a repetition of the process results in a big crack in the side wall. The prevention of this is found in the practice of making the rods long enough to extend through the entire side walls, from front to rear, with large washers or buckstays at the rear, and when the nuts are screwed up properly, there is little chance for the walls to crack. The last horizontal return-tubular boiler that I set was stayed in this manner, and no cracks have appeared.

New Haven, Conn. W. H. WAKEMAN.

Cause of a Split-Phase Motor Burning Out

A single-phase alternating-current induction motor is not self-starting unless some auxiliary starting means are provided. One method of making such motors self-starting is by the use of a split-phase winding. There are two windings in the stator. One, the main winding, is designed to carry the full-load current and remains in circuit all the time the motor is connected to the line. The other, the starting winding, has a high resistance and is designed to remain in circuit only during the starting period. This winding has a smaller number of turns than the main winding and is cut out of circuit by a centrifugal switch mounted on the rotor, when about 85 or 90 per cent normal speed is reached. It is essential that this switch open and cut the starting winding out of circuit when the motor comes to near normal speed, or this winding will be burned out in a short time

In one case when the switch on a motor had to be replaced by a new one, the starting winding burned out shortly after the motor was put into service. The starting winding was replaced and the motor put into service, when this winding again burned out. The second burn-out left the main winding in such a condition that the two windings had to be replaced. When the motor was again put into service, an investigation revealed that the centrifugal switch did not open when the motor came up to speed. On further investigation it was found that the new switch was intended for a 3,500-r.p.m. motor, whereas the machine on which it was installed operated at about 1,750 r.p.m. The spring tension was adjusted so that the switch would open at

a speed below that of the motor, and no further trouble was experienced.

In machines of the split-phase type when they come up to speed, a distinct click can be heard when the switch opens. The absence of such a click is an indication that the switch has not opened, which should be investigated. If the switch does not open and cut out the starting winding, the motor will have a peculiar hum and act distressed. Such conditions should always be investigated before the windings have time to be damaged. CHARLES A. ARMSTRONG.

New York City.

Help Your Fellow Engineer by Writing for the Journals

There are thousands of engineers, helpers, oilers and mechanics whose daily duty it is to help keep the wheels of industry turning. Every day of the year some of this army of men are encountering problems and difficulties of an engineering nature. New conditions and developments take place in the engineering field from time to time. Changes in equipment and improvements of methods must be made. These problems must be solved and disposed of satisfactorily. Breakdowns are constantly occurring. Out of the ordinary repairs are made, and ingenious makeshifts are often resorted to in emergencies. Kinks and small improvements that add to the efficiency or smooth operation of the plant are devised almost daily.

A majority of these men subscribe to one or more engineering journals pertaining to their particular line of work. The feature articles are read with interest. They like to keep abreast of new developments in the power field, new plant layouts, old plants remodeled and brought up to date. The "Practical Ideas" department is always of special interest. They are anxious to learn new tricks of the trade and how the other fellow keeps things above par. They do not realize, however, that a small minority of the men engaged in the business of engineering contribute the bulk of the reading matter so earnestly read by them from month to month.

There is a deplorable lack of technical writers in the engineering field today. Many engineers have a horror of writing for publication. They imagine that it is beyond their capabilities to turn out a readable article. They fear to see something in print with their name attached thereto. But it is really not a difficult matter at all. Trade journals are always on the lookout for something of interest to their particular reading public, and articles or sketches that can meet these requirements are seldom rejected.

A large part of an engineer's knowledge is gained by actual experience. Almost every mechanic can recall a number of experiences that would be extremely interesting and beneficial to others in the same line of work. They have met difficulties and worked them out, and the solution was not always to be found in the regulation manual or handbook. It is just such information that should be gladly given to others through the medium of the trade journal. Especially the young man in the engineering game might be saved much worry and trouble by receiving a few helpful hints from someone who has mastered emergencies that the young man may not be able to foresee. Don't hoard the results of years of experience. While you may have had to wade out of your own difficulties (and most of us do), you cannot deny that you might not be occupying your present position today had it not been for the helpfulness of others.

Sit down and make a sketch of that change in piping or other change you made in the boiler room that so improved the operating condition of your plant. Write out simply and briefly just what you did in the way of overhauling that old engine or other equipment. These and a hundred other items make valuable reading to engineers and supply information that can usually be gained only through practical experience.

A trade journal is valuable to its readers only as such readers make it so. It is the exchange of ideas and opinions of men in the same field of labor published in the journals that creates discussion and interest among engineers. So write up that unusual experience and send it to your favorite trade paper. In addition to being paid for your trouble, you will have the satisfaction of knowing that you have contributed your bit toward helping someone over a hard place.

With all these advantages on the credit side of technical writing, there is no just reason why every engineer should not contribute something to the benefit of fellow engineers. A. R. KNAPP.

Louisville, Ky.

Wanted, A Substitute for Loofah Sponges as a Filtering Medium

It might be of interest to some readers of *Power* to know that about all the feed water used in the boilers of a sugar mill is the water from the evaporators or the water content of the cane juice, together with some of the condensed steam from the engines.

Upon taking charge of the boilers at this central, oil was found in all the boilers. The oil had combined with other impurities to form a heavy deposit of carbon on the tubes.

Plans were made immediately for constructing a filter to remove the oil from the water. In the used-material storage we found a piece of cast-iron pipe, 42 in. in diameter and 10 ft. 6 in. long. We had two sheet-iron heads made and braced with angle iron. Then two 10-in. holes were cut in one of the heads and nipples welded in one above the other.

We then secured a piece of sheet steel and cut it to form a diaphragm the length of the pipe, perforating the last two feet with small holes. About 18 in. from the inlet and outlet end we placed perforated baffles to form a vertical strainer. The pipe was finally placed horizontal with the outlet at the bottom.

Loofah sponges were placed above and below the diaphragm up to the vertical strainers. Water from the pressure hotwell, which is located just above the filter tank, flows over the top of the diaphragm through the perforated plates at the back end and along the bottom to the vertical plate at the front end. The filter operates under a pressure of about 5 lb. and a temperature around 220 degrees.

It was a big surprise to all to see the amount of oil in the feed water even though oil extractors are used on the exhaust lines. The filter is a big success, although we have to change the sponges every three weeks. We would like very much to find a cheaper medium for this work. Probably some reader of *Power* can suggest an equally effective, but cheaper medium and one that will not require changing so often.

Central Elia, Cuba. EDWIN C. BLISS.

Comments from Readers

The Master Mechanic

Judging from a letter in the Oct. 7 issue, the Foreword in the Aug. 26 issue, entitled "The Master Mechanic," must have disturbed the ethical standing of one of *Power's* readers.

I find nothing objectionable in the article referred to, because it indicates to me a trusted employee who had his employer's confidence, with a well-balanced organization, which handled all details and allowed him time for constructive planning. I have seen many men who would have accomplished more had they done less walking and more intensive thinking in the office.

If I were in such a position that I had to spend my time on such details as checking up accidents and their prevention, sanitary conditions, and prevention of breakdowns, I would consider that my organization either needed a shaking up or a new department head.

W. A. ARMES,
Construction Superintendent,
Niagara Falls, N. Y. Domill Construction Co., Inc.

Keep the Hoist-Limit Switch in Operation

With reference to the editorial in the Sept. 30 issue entitled "Design of Safety Device Depends on Operator and Inspector," I should like to take exception to a sentence in the second paragraph, as follows: "Apparently, in some instances less damage and better satisfaction resulted by removing the hoist-limit switches altogether and placing the entire responsibility on the operators."

In nearly five years of service with a crane builder I do not know of one single hoist that has been shipped without a limit switch. Moreover, this firm has repeatedly declined to build such a hoist, even when urgently requested to do so by a customer. It is my opinion that no crane hoist should ever be operated without adequate over-travel protection in the form of a limit switch. I also feel that the publication of the statement previously referred to is dangerous in that it gives a semblance of authority for an operator without adequate skill or judgment to remove the limit switch or otherwise render it inoperative.

Some two years ago I had an experience that will well illustrate the point. On calling at a large power plant to inspect a coal-handling bucket crane, the plant electrician stated that he had removed the limit switch because it was in the way and he had great confidence in the skill of the operator and his ability to prevent any accident. I ventured a protest and stated that my firm did not approve such practice, even with the most skillful of operators. We then went into the operating cab to watch the operation of the crane.

The gondola car being unloaded was nearly empty, and three or four laborers with shovels were cleaning the corners at one end while the bucket was working at the other end. Three or four round trips were made successfully, when one of the hoist controllers jammed on the hoisting motion and could not be returned to neutral. The lift was so short that before the operator could trip the main-line circuit breaker immediately to his right, or open the main-line switch just behind him, the bucket hit the trolley separator, the ropes were pulled out of the clips and the bucket with 2 cu.yd. of coal dropped back into the car. Luckily, no one was injured and no damage was done aside from fraying the ends of the steel cables and putting the crane out of commission for an hour or so while the ropes were repaired. But, if the limit switch had been in operation, it would have prevented what might have been a fatal accident to one of the laborers in the car.

H. W. BAKER, Electrical Engineer,
Harvey, Ill. Whiting Corporation.

The Venturi Meter for Ammonia

I have read with much interest the editorial in *Power* of Sept. 2 entitled "Flow Meter Needed for Refrigerating Plant," also the article on the same subject by Charles G. Richardson in the Oct. 28 issue.

Likewise, I have followed closely, published articles appearing elsewhere on this topic which have included the results of several tests that have been made from time to time to determine the accuracy and dependability of the venturi meter in connection with the measurement of liquid ammonia in the refrigerating plant.

There appears to be a considerable honest difference of opinion among refrigerating engineers on this subject, and it is entirely right and proper that the members of the engineering profession should take the position of wanting satisfactory proof that such instruments are accurate within practicable limits when used under the conditions such as ordinarily obtain in the well-managed ice-making and refrigerating plants.

I believe, however, that any device having such possibilities as the venturi meter for improving operation in such plants and affording a check on plant performances such as cannot be had by other methods except at considerable expense, should be heartily encouraged.

Would the large steam-electric stations be willing to operate without their usual quota of precision instruments which give them a record and a check on boiler, turbine and generator performance? I hardly think so. Ice-making and refrigerating plants, by reason of the fact that, until recently having no practicable methods for checking up performances and quickly determining efficiencies, have had to muddle along somehow and do the best they could, and it would seem that anything that would tend to improve matters in this respect should be given every chance to develop and all encouragement possible.

I am fully aware of the value of the ammonia indicator, the dependable thermometer and the pressure gage in such plants and appreciate that no plant should be without these essentials, but unfortunately, they are not sufficient in themselves and if possible should be

augmented by dependable meters for accurately measuring refrigerating fluids.

I am neither a manufacturer nor a manufacturer's representative, but only an engineer; however, I feel that the manufacturers of such instruments as the venturi meter for measuring liquid ammonia in the refrigerating plant deserve greatly of mankind.

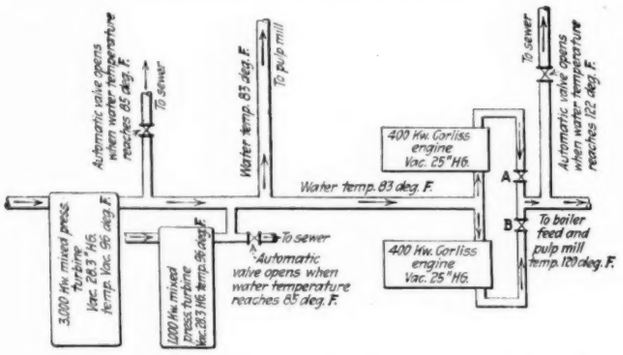
Atlanta, Ga. C. T. BAKER.

Saving Fuel in Industrial Plants

I read with interest Andrew F. Sheehan's article in the Sept. 2 issue, entitled "Large Saving Possible in Industrial Plants by Use of High-Pressure Steam."

I agree with him that high steam pressures would be economical in an industrial plant from the viewpoint of fuel consumption, and I believe that in the near future we will see many industrial plants with steam pressures of 400 to 600 lb. I also agree with Mr. Sheehan, that for economical operation the paper machines should be motor-driven and all auxiliaries except such as boiler-feed pumps, where, for safety and reliability, it is desirable that at least part of the units be steam driven.

I would also stress the point that in plants where steam turbines are operated, for the sake of economy


Automatic valve opens when water temperature reaches 85 deg. F.
To sewer
Water temp. 85 deg. F.
To pulp mill
To sewer
Automatic valve opens when water temperature reaches 122 deg. F.
400 Kw. Corliss engine Vac. 25" Hg.
Water temp. 83 deg. F.
A
B
To boiler feed and pulp mill temp. 120 deg. F.
3,000 Kw. mixed press turbine Vac. 26.3" Hg. temp. Vac. 96 deg. F.
1,000 Kw. mixed press turbine Vac. 26.3" Hg. temp. 96 deg. F.
To sewer
Automatic valve opens when water temperature reaches 85 deg. F.
400 Kw. Corliss engine Vac. 25" Hg.

Arrangements for recovering heat absorbed by the circulating water

and to prevent rapid erosion of turbine blades, superheated steam should always be used.

I am familiar with an installation where the turbine operated several years on superheated steam with very little signs of blade erosion. It was then operated for about six months with saturated steam, and at the end of that period the blades were so badly eroded that they almost warranted reblading.

However, in considering high pressure and temperature for an industrial plant, we must not lose sight of the fact that reliability and continuity of service are even more important than fuel economy. Mr. Sheehan recommends that the paper mill in question have two high-pressure boilers. Part of the time at least, the load would have to be carried on one of them at 200 per cent rating. In such an installation it would be difficult to maintain a constant steam pressure and temperature, especially if the boilers are hand fired or the stokers are of a type that utilize a dumping grate. Yet a small change in steam pressure and temperature might suffice to change the speed of the prime mover and hence the frequency, which might cause serious trouble on a motor-driven paper machine. Variations in the speed of a paper machine may not only result in inferior paper and a large percentage of "broke," but may cause serious damage to the machine itself, such as a broken wire.

Mr. Sheehan says: "As a low water rate is necessary and it is also necessary to operate non-condensing, a reciprocating engine will be the logical choice." Personally, I should prefer a high-pressure turbine in place of a reciprocating engine for the following reasons: (a) Although an engine could be built to be as economical as a high-pressure turbine for a given load, a turbine is more economical with a widely fluctuating load, especially if the unit is overloaded; (b) the first cost of a turbine is less; (c) a turbine could be more easily designed to operate with high temperatures, which might cause serious trouble in cylinder expansion and cylinder lubrication of the steam engines; (d) a turbine would require less building space.

In paper mills operating in conjunction with pulp mills, artificial silk mills, tanneries, etc., where large quantities of warm water are required, a considerable saving can be effected by utilizing the warm condenser circulating water. Condenser designers allow for 950 B.t.u. being extracted from each pound of steam condensed. This is approximately true for average conditions.

The accompanying diagram illustrates how one pulp mill recovers a large amount of the heat extracted from the steam in the condenser. The approximate temperatures and vacuums are given in the illustration. The three outlets to the sewer are controlled by automatic valves that open when the circulating water reaches a certain temperature. This arrangement insures a good condenser cooling-water temperature at all times.

It will be noticed that the vacuum on the different units is as high as could be desired, yet the water has been heated considerably. This system has been in successful operation for several years and has been the means of considerable saving in fuel.

I judge that the paper mill described by Mr. Sheehan does not include a pulp mill, and a paper mill does not require much warm water. However, assuming that the warm water required is equal to 80 per cent of the condenser circulating water, which would be approximately true for many pulp-paper mills,

Pounds of steam condensed per hour $\times$ amount of heat extracted from 1 lb. steam $\times$ 80 per cent = B.t.u. saved per hour; $14{,}500 \times 950 \times 0.80 = 11{,}020{,}000$ B.t.u. saved per hour. Assuming that the heating value of the coal used is 13,000 B.t.u. per lb. as fired and that the boiler efficiency is 80 per cent, then $\frac{11{,}020{,}000}{0.80 \times 13{,}000} = 1{,}060$ lb. of coal saved per hour, or approximately 11.5 long tons per day; $11.5 \times \$7.50 = \$86.25$ saved per day; $302 \times \$86.25 = \$26{,}047.50$ saved per year. The plant now uses 35 long tons of coal per day. $\frac{11.5}{35} = 32.8$ per cent coal saved. That is, 32.8 per cent of the fuel, or $26,047.50 per year, could be saved by recovering 80 per cent of the heat extracted by the condenser cooling water compared to a saving of $42,000 from the method proposed by Mr. Sheehan.

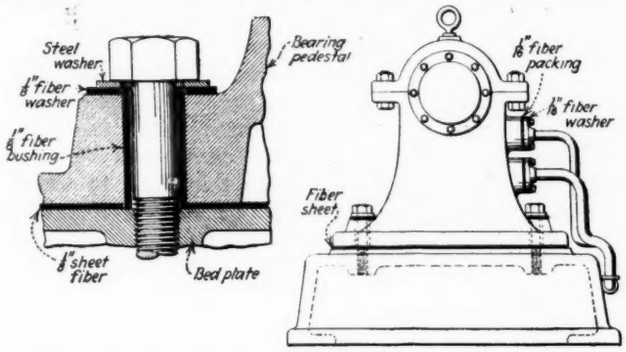
However, the method outlined would show an appreciable saving only in plants requiring large quantities of warm water, while high-pressure steam could be utilized in practically all industrial plants.

Tyrone, Pa. GEORGE E. GASTER.

Insulating the Turbine Outboard Bearing To Stop Flow of Induced Current

In the Sept. 23 issue, Claude C. Brown, in an article entitled "Operating Steam Turbine Generators," suggests the use of lightly bearing copper bushes on the generator shaft to stop the flow of induced current through the journals and bearings.

About a year ago we experienced this trouble on a 5,000-kw. unit, but it was not discovered until considerable pitting had taken place in the generator bearings. Our first indication that induced current was flowing through the shaft and journal was when a flash was noticed by the operator to take place from the vertical shaft driving the oil pump to the surface of the oil in the base of the turbine.



How bearing was insulated to stop flow of current

As a means of permanently overcoming the trouble, we decided to insulate the outboard bearing pedestal as shown in the illustration. A piece of sheet fiber was inserted between the pedestal and bedplate, and the holding down bolts were insulated by means of fiber bushings and washers, as clearly shown in the detail at the left of the figure. The same method was used on the oil-pipe flanges and bolts. The ordinary packing on the pipe flanges was replaced with a fiber gasket well coated on each side with shellac just previous to putting into place.

This method of insulating the bearing stopped the flow of current and consequently the pitting action.

Boston, Mass. J. W. SLOANE.

Will Zinc Stop Corrosion?

Marine boilers in ocean service are subject to corrosion because the feed water cannot be kept entirely free from sea water, galvanic action resulting. At one time it was thought that this was entirely responsible. We now know, by noting the following reactions, that free air in solution, salts or acids in small quantities in the feed water will cause corrosion:

(1) $4Fe + 3O_2 + NaCl + H_2O \rightarrow 2Fe_2O_3 + NaCl + H_2O$
(2) $2Fe + 6NaCl + 6H_2O \rightarrow 2FeCl_3 + 6NaOH + 3H_2$
(3) $2Fe + 6HCl \rightarrow 2FeCl_3 + 3H_2$
(4) $2Fe + 3H_2SO_4 \rightarrow Fe_2(SO_4)_3 + 3H_2$

Zinc plates have and are being used extensively in marine service to arrest this action. Zinc prevents the solution of the iron by forming an electric couple, as all the zinc will dissolve before any of the iron. This assumes, of course, that perfect electrical contact is maintained between the zinc plate and the metal of the boiler, which is possible by exercising care in design and by frequent inspection.

If zinc and iron are present together, in perfect electrical contact, in a solution containing either salts or acid, or when air is in solution, the following reactions occur:

(1) $Zn + 2HCl \rightarrow ZnCl_2 + H_2$
(2) $Zn + H_2SO_4 \rightarrow ZnSO_4 + H_2$
(3) $2Zn + O_2 + H_2O + NaCl \rightarrow 2ZnO + NaCl + H_2O$

River waters form a supply from which the boiler-feed water is taken for many plants. These rivers in some localities are high in acid and salts, as they are the means of drainage for mines, mills, chemical plants and other industrials. Extensive systems are used to treat this water, but it is almost impossible to treat it so that it will be neutral at all times. Also, leaky condenser tubes admit bad water to the condensate.

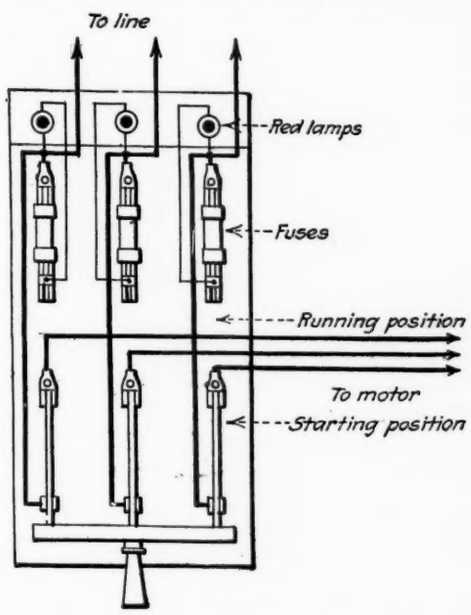
Since zinc plates properly installed will eliminate corrosion, as indicated by their continued use in marine service, why is there not more general use of these plates in the boilers of stationary plants.

Have cases where zinc plates have been used in such plants, developed experience to disprove this belief, particularly with waters containing organic matter?

Wheeling, W. Va. J. H. KAYLOR.

Signal for Indicating When a Fuse Blows on Induction Motors

I was much interested in the article by W. H. Hornsberger in the Sept. 30 issue, entitled "Signal for Indicating When a Fuse Blows on Induction Motors," as we have used a system of signals similar to the one shown by Mr. Hornsberger which is reproduced herewith, on six induction motors ranging from 20 to 50 hp. for the past two years.



Lamps light up when fuses blow

The first three years these motors were in service, considerable money was expended in replacing coils, but since installing the signal no coils have been replaced in either motor. We not only consider the signal a safeguard for the motors, but it saves considerable time in replacing fuses if an interruption does occur, as it is at once apparent which fuses are blown

Philadelphia, Pa. A. B. BROWN.

QUESTIONS AND ANSWERS

Conducted by Franklin VanWinkle

Rocking Valve

What is the arrangement of a single rocking or oscillating valve for controlling admission and exhaust of steam from the cylinder of an engine? R. M.

As indicated by the circle, Fig. 1, the face of the valve *V*, in place of being flat, like an ordinary D slide-valve, is turned off to match the bore of the valve seat, shown as the inner circle of the longitudinal sectional view of the engine cylinder, Fig. 3. A square portion of the valve spindle *P*, Fig. 1, also shown in Fig. 2, engages with a slot along the back of the valve. Oscillation of the valve spindle and valve is imparted by an

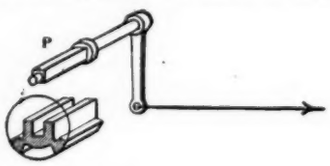


Fig. 1—Rocker valve and spindle

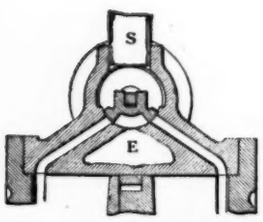


Fig. 2 — Longitudinal section of cylinder and cross-section of valve and seat

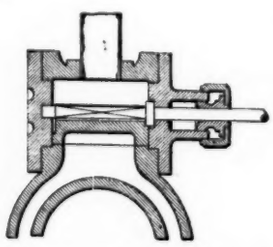


Fig. 3—Cross-section of cylinder and longitudinal section of valve

arm *A*, Fig. 1, which is connected to the eccentric rod indicated by the arrow, Fig. 1, so that in place of the eccentric imparting a rectilinear reciprocating motion to the valve spindle, as in case of a D slide-valve, the valve is rocked on its axis.

Steam supplied at *S*, Figs. 2 and 3, on top of the valve is thus distributed to the steam ports and the exhaust passage *E*, Fig. 3, the same as by a flat-seated slide valve. With sufficient depth of the slot that receives the square part of the valve spindle, the valve is free to find its seat under the action of the steam pressure, or may be raised off its seat by water forced back from the cylinder of the engine. The "D" form of rocking valve is rarely used except on small engines. When rocking valves are used on large engines, the usual practice, as in the Corliss engine, is to provide a valve for separate control of admission and exhaust at each end of the cylinder, with each valve in control of a single steam passage connected with the cylinder, thus dispensing with the large clearance space that is introduced by the steam passages in the cylinder when a single valve is used, and also permitting of independent adjustment of admission and exhaust for each end of the cylinder.

Saving from Use of Economizer

Our boilers evaporate 56,883 lb. of water per hour into steam at 145 lb. gage with feed-water temperature 140 deg. F. What would be the per cent of saving if the feed water, before entering the boiler, is raised in an economizer to the temperature of 200 deg. F.? J. M.

A pound of steam at the pressure of 145 gage, or 160 lb. per sq.in. absolute, contains 1,194.5 B.t.u. above 32 deg. With feed water at 140 deg. F., each pound of the feed water contains 140 — 32 = 108 B.t.u. above 32 deg. F., and for generation into steam at 145 lb. gage each pound of the feed water must receive 1,945.5 — 108 = 1,837.5 B.t.u. If, with the same combined efficiency of boilers, furnaces and grates, the economizer increases the feed-water temperature from 140 deg. F. to 220 deg. F., each pound of feed water for generation of steam would need to receive 220 — 140 = 80 B.t.u. less, and the fuel saving would be $\frac{80}{1,837.5}$ = 0.0435, or roundly about 4½ per cent.

Preventing Corrosion of Copper

Part of our electrical equipment is installed where it is exposed to acid fumes which cause exposed copper parts to corrode. Is there something that can be applied to prevent this corrosion? M. H.

Tinning the exposed parts with solder will have the desired effect. This may be done with a soldering iron, a blow-torch or by dipping the parts into molten solder. Another method is to apply a coat of vaseline to the exposed parts. This will have to be renewed about once a month and will work satisfactorily unless the temperature of the parts is hot enough to thin the vaseline so that it will run off.

Transparent Bakelite lacquer has been used with good results. Only a thin coating of this material is required and can be applied with a brush, by spraying or by dipping. Before the lacquer is applied the surface should be thoroughly cleaned. Best results will be obtained by placing the coated parts in a bake oven for a few minutes after the application. The oven should have a temperature of about 300 deg. F. Another material that may be used is air-drying armature varnish. The parts to be treated should be thoroughly cleaned and heated to about 125 deg. F. before the varnish is applied.

Here and There in the Power Plant

Sidelights on things generally used but less generally understood

The Revival of Air Preheating

THE idea of using the waste heat in flue gases to preheat combustion air is by no means new. About forty years ago an air heater was constructed and tested in Massachusetts in connection with a horizontal-return-tubular boiler. The apparatus showed a substantial saving of fuel, yet it was dropped and so completely forgotten by the profession that the average stationary[1] engineer of today looks upon the air preheater as something entirely new. A few years ago this apparatus was revived in Europe, and within the past year or two it has been placed definitely upon the map in American practice.

Is Air Preheating a Fad?

What is the reason for this revival? Is it a fad; did the engineers of an earlier generation pass up a good bet; or have conditions so changed that the air heater is now a better investment than it was in former days? The last explanation seems nearest the truth. Conditions have changed markedly, and in these changes is to be found, in the opinion of many competent engineers, adequate excuse for the revival of the air heater in new and improved forms.

The outstanding difference in general conditions is the great increase in the cost of fuel, which, taken by itself would seem to justify a corresponding increase in investment to save a given amount of fuel. Operating in the opposite direction is a general increase in the cost of all kinds of machinery, particularly since the war. But this increase, though large, is by no means as great as that of the fuel cost.

Two factors have operated to increase the cost of fuel more rapidly than that of the apparatus designed to transmute heat into power. One is the growing scarcity of fuel, which has increased its cost faster than that of commodities in general. The other is the generation of power in larger and larger units.

The net result of these factors is that a piece of fuel-saving apparatus which would not have paid its keep twenty years ago may now be a profitable investment.

What has been said so far might apply to almost any piece of power-plant apparatus. There are certain additional factors that apply particularly to the air preheater.

It is well known that the largest loss in the operation of a steam boiler is that due to the sensible heat in the enormous volume of hot gases passing up the stack. For every ton of coal burned, from twelve to twenty-five tons of gases pass up the stack, depending upon the nature of the fuel, the type of furnace, method of firing, skill of the operator, etc. With a flue temperature of 500 deg., the heat carried away by this gas would be equivalent to from 200 to 400 lb. of coal. It is evident that any piece of apparatus or method of operation that presents an opportunity to recover a large part of this loss is worthy of careful consideration.

The first thing to be done in any case is to cut the excess air down to the practical minimum by intelligent firing in properly designed and tightly constructed settings. The next is to insure the minimum flue temperature by clean heating surface and tight baffles.

When these remedies have been carried to the practical limit, there will still be a substantial loss of fuel in the hot flue gases. In fact, there would be a loss even in a theoretically perfect boiler with an infinite heating surface, which would at the best throw to waste (per ton of coal) about eleven tons of flue gas at the temperature of the steam, since it is obvious that the boiler tubes can never cool the gases below the steam temperature. Attempts to approach this limit too closely result in commercial loss, because the added heating surface does very little additional work.

Bleeder Heating Limits Economizer

Beyond a certain point additional heating surface will not "pay its keep" except in some sort of heating device where the temperature of the substance to be heated is well below that of the steam in the boiler. For this purpose the economizer is extensively used. If there were no other considerations than the thermal efficiency of the boiler plant alone, the ideal combination in every case would be a boiler used in connection with an economizer fed with water at room temperature.

By constructing the economizer on the counterflow principle, the final flue temperature would be very low and the combined over-all thermal efficiency of the boiler plant correspondingly high, assuming reasonably good operation in other respects. In practice the feeding of the economizer with cold water would not ordinarily be practicable on account of sweating and corrosion. Moreover, except in a very few plants where all the steam is delivered directly to processes from the boilers, with no hot returns, cold feed water could be supplied only at the expense of the efficiency of some other part of the plant. This is an important consideration. The ordinary small power plant, for example, has exhaust steam available to heat the feed water practically to 212. Failure to use this steam to heat the feed water would increase the boiler-room efficiency, but decrease the efficiency of the plant as a whole.

In large stations with electrically driven auxiliaries it is now general practice to heat the feed water with steam bled from the turbines at from two to four stages. Good turbine-room efficiency requires the heating of the feed water to a fairly high temperature in this manner.

On the other hand, the hotter the feed water the closer do the conditions in the economizer approach those in the boiler itself. Hotter feed water militates against the economizer in two ways. In the first place it cuts down the rate of heat absorption per square foot or increases the cost of an economizer to do a given amount of heating. In the second place it reduces the possible amount of heating that can be done in any economizer, since the water must be taken into the boiler at a little below the saturation temperature.

Air Heater Is the Solution

There are at least two known ways around this difficulty, and others may be developed as engineers continue to study the problem. One is to heat the feed water to a moderate temperature only, using the steam bled from the higher stages of the turbines for preheating the combustion air. The other is to employ an air heater to return part of the waste flue heat to the furnace as preheated combustion air.

Depending on the type of heater and the conditions under which it operates, the air heater will return to the furnace air from 30 to 70 per cent of the heat in the flue gases. Tests to date indicate that the gain in over-all efficiency is somewhat greater than would be expected from the amount of heat directly recovered. On the other hand, the increased temperatures have caused designers of stokers and furnaces some concern as to the effect on materials. For this reason it is possible that the general adoption of air heaters will have some influence on the design of furnaces and stokers.

Tests made at Colfax last year showed an over-all gain in boiler and furnace efficiency of about six points by the use of air heaters. As already suggested, the air heater should also be credited with an additional gain in over-all plant efficiency due to the feasibility of heating the feed water to higher temperatures with bled steam where no economizer is used.

[1] Air heaters are better known in marine service.

Interconnection of Power Systems in the Southeastern States*

By W. E. MITCHELL
Assistant General Manager, Alabama Power Company

IN LESS than ten years nearly all the power companies will be faced with the problms of interconnection, power interchange and the operation of interconnected systems. While these problems differ in detail in different parts of the country, there are certain elements in common. For this reason a review of what has been and is being done in the Southeastern States may be of interest.

The territory embraces Mississippi, Alabama, Tennessee, Georgia, North and South Carolina. The principal power companies in the territory are Southern Power Co., Carolina Power & Light Co., Georgia Railway & Power Co., Central Georgia Power Co., Columbus Electric & Power Co., Alabama Power Co., Birmingham Electric Co., Tennessee Electric Power Co. and Memphis Light & Power Company.

At present the capacity of the interconnected systems is 782,000 kw. of hydro-electric and 353,000 kw. of steam-generating stations and 225,000,000 kw.-hr. of hydro storage capacity. In 1923 the output of these systems was 3,250,000,000 kw.-hr. with a maximum load of 740,000 kw. According to the best data available these figures will be doubled in 1930.

Interchange of Power Proved Successful

Interchange of power between the Southeastern power companies proved so successful that about 18 months ago executives of the various power companies decided that still closer co-operation would be beneficial. An operating subcommittee was formed with one representative from each company's operating department. This committee meets once a month, exchanges information on load and rainfall conditions, energy generated on each system by hydro and steam and discusses such matters as voltage regulation, load dispatching and system protection.

The work of this committee has proved of very definite benefit. Its successful work has caused the executives to go a step farther, and an engineering subcommittee has now been formed, consisting of the chief engineer or executive engineer of each company, and studies are being made of the possibilities of a co-ordinated development program, with the object of avoiding construction of two or more large plants by different companies at the same time, if one development plus interchange will handle the load. In this manner one company might save the fixed charges on a very large investment for two or three years while the other company would load its new development from the date of completion with not greatly increased operating costs. Under such circumstances it ought to be possible to work out a mutually advantageous interchange.

While this engineering committee has just organized, there is every reason to expect good results. An assistant engineer or a computer from each company is assigned to the work, and these men are putting in full time in the same office assembling data on stream flows, studying rainfall and run-off records, plotting present load curves for both wet and dry seasons and projecting the growth of each company's load for the next ten years and determining the proper sequence of developments to carry the loads. While the proximity of the various systems and the necessarily restricted location of large steam reserve plants may make this a more immediate problem in the Southeast, I believe the principles involved are applicable to advantage elsewhere.

Value of Engineering Studies

These statements show the value of having an engineering committee working on a co-ordinated study of all available resources and their most economical development. After the engineers have completed their estimates of what the tie lines will cost and the operating men have worked out their scheme of operation, an interchange contract must be made before the lines can be built and power interchange actually take place. Upon the type of agreement between the interconnected companies is largely dependent the success of the project and its most economic use.

Quite naturally, the first tie lines were built to enable a company having a surplus of energy to sell it to another that was short of power. Following this came agreements covering emergency service, and later agreements for straight interchange. All these different conditions must be covered by contract and rates established. Furthermore, rates must be varied, dependent on whether surplus or dump power, steam power, with a clause varying the rate as the price of coal varies from the base price, or hydro storage power is being supplied. It is readily seen, therefore, that the drawing of a contract is not simple.

Method of Billing for Interchange of Power

Fortunately, after the contract is drawn with all its legal phraseology, carefully protecting every right of both parties and arranging at great length for the arbitration of disputed points, it is usually forgotten, except the rate clause, and operation under it is decidedly simple. The method of billing for the energy under these contracts is interesting, showing how simple a complicated problem can sometimes be made. For example, power destined for the Carolina Power & Light Co. is delivered by the Alabama Power Co. to the Georgia Railway & Power Co. at the state line and is in turn delivered by the latter to the Southern Power Co. at Tallalah Falls and by the Southern Power Co. to Carolina at Wateree. Only one bill is rendered and that by the Alabama Power Co. against the Carolina Power & Light Co. for the full amount of power delivered to the Georgia Railway & Power Co. at the state line. To compensate for line losses, the Georgia Railway & Power Co. and the Southern Power Co. deduct a percentage of the power delivered to them for transmission and pass on the remainder to the Carolina Power & Light Company.

Interchange contracts under which one company supplies power at night at one rate and gets it back in the daytime at a higher rate are common. Nearly all interchange contracts are optional on both parties. That is, if *A* has power to sell and *B* desires to buy, power moves; otherwise it does not, and vice versa.

In transmitting power in blocks of 15,000 to 25,000 kw. over tie lines, power-factor correction is absolutely essential. It is desirable to operate these lines at as near unity power factor as possible. Synchronous condensers are being installed on the various systems for power-factor correction. During the year 1923 the Alabama Power Co. installed on its system approximately 20,500 kva. in synchronous-condenser capacity, and during 1924 an additional 27,500 kva. will be installed. These condensers, of course, are located near the load centers to secure the maximum possible benefit of power-factor correction.

Turbo-Generators Operated as Synchronous Condenser

The Alabama Power Co. is installing a 25,000-kva. turbo-generator at its Gorgas steam plant, and provisions are being made for disconnecting the generator from the turbine and operating the generator as a synchronous condenser. This is especially desirable, since in the wet season the steam plants are shut down, and as the hydro plants are located in the opposite section of the system, operation of the generator as a condenser improves conditions throughout the system.

During the dry season hydro generators are floated on the system for power-factor correction. By shutting the wicket gates and breaking the vacuum in the draft tube on the machine, it is possible to operate generators for power-factor correction with only a small loss of water. This same practice is, of course, followed by other companies on the interconnected network, and the system supplying energy is relieved, so far as possible, of excess reactive component by the systems receiving the energy, these systems using their spare generator capacity for power-factor correction. Although without doubt the proper place for the

*Abstract from a paper presented at the Pacific Coast Convention of the American Institute of Electrical Engineers, Pasadena, Calif., Oct. 13-17, 1924.

major part of power-factor correction is at the customers' load, a certain amount of correction is necessary in large load centers where large-capacity condensers can be installed and definite control of voltage conditions can be secured.

In general, 110,000-volt oil circuit breakers are used for synchronizing purposes. Inherently, these breakers are slower than the low-voltage breakers in generating stations; however, with a little practice the operators are able to synchronize systems with no adverse effect to either of the systems. Of course it is necessary to carefully check circuit-breaker adjustments so that at all times they will close as quickly as possible.

To operate the transmission systems in parallel successfully and at the same time secure the proper load adjustments between the various generating stations and between the systems themselves, it is essential that the frequency be rigidly maintained at 60 cycles. At first some difficulty was experienced in maintaining a fixed frequency, and on numerous occasions in the early days of the operation frequency variations were such as to overload the tie lines to such an extent that the overload relays tripped out the switches, separating the systems. Some difference was always found in the frequency indicators in spite of careful calibration, but this difficulty has been overcome by the installation of Warren master clocks either at the principal regulating stations or at the load dispatcher's office. The master clock makes it possible to maintain an average frequency within very close limits.

It has been found that the regulation of frequency must be controlled by the base-load stations and especially the base-load station of the system supplying the bulk of the power, all other stations making the necessary governor adjustments to fall in step. The governors at all stations taking the load fluctuations should be equally sensitive, so that systems can properly carry their share of the fluctuations.

On the system of the Alabama Power Co. the base load is carried by hydro plants and load fluctuations by steam plants in the wet season, and vice versa in dry seasons. During the wet season, therefore, the frequency is controlled at Lock 12, and in the dry season it is controlled at the Gorgas Steam Plant. Master clocks are installed at both stations for controlling the frequency. There is no appreciable difference in the manner in which the hydro and steam stations handle load fluctuations.

Operation is handled between load dispatchers on the various systems. It has been found advisable to establish a central load dispatching point at Atlanta, and all messages concerning the dispatching are usually relayed through Atlanta to the interested systems. If a company desires to purchase energy, the operating superintendent or engineer customarily advises the central load dispatcher of the amount of power desired on interchange and this is relayed to the dispatchers of the proper systems. In case of emergency the load dispatchers have authority to act, and it has frequently been possible to save very important loads by quickly bringing in additional generating capacity. In this way interruptions due to line trouble are reduced in number and duration, because in most cases important load centers can be served over two entirely different routes.

The St. Lawrence Deep Waterway to the Sea

AT THE fall meeting of the American Society of Civil Engineers held in Detroit from Oct. 22 to 25, the major subject of the convention was the St. Lawrence Deep Waterway to the Sea. As an introduction Francis C. Shenehon, consulting engineer, of Minneapolis, presented a comprehensive paper incorporating some general principles involved in the best co-ordination of navigation and water power, taking into consideration the whole Great Lakes System. The major portion of the paper is devoted to those elements of the problem not within the purview of the 1921 report, which is now being reviewed by a new international board of engineers. An abstract of the paper and the major points of the ensuing discussion follow:

In the paper, the St. Lawrence Deep Waterway to the Sea is visualized as the right of way leading to the Gulf of St. Lawrence from Duluth and Port Arthur near the head of Lake Superior and from Chicago at the extreme south end of Lake Michigan. This waterway to the sea contemplates a deep-draft navigation of perhaps 25 ft. at first and later 30 ft. One of the outstanding features of this project is the improvement of the St. Lawrence River between Montreal and Lake Ontario. In 115 miles of this river there is a fall of 224 ft. with a normal flow of 230,000 cubic feet per second.

Estimates based on 210,000 cu.ft.-sec. flow and an over-all efficiency of 88 per cent for the generating units give the power that can be generated in the proposed improved section of the St. Lawrence River at 4,064,000 hp. Of this amount 1,464,000 hp. is developed on the international section of the river.

Mr. Shenehon prefers to base his estimates on 200,000 cu.ft.-sec. flow and a generating unit efficiency of 84 per cent, which would give 3,600,000 hp. in the 115 miles of proposed river improvement.

It was the speaker's opinion that water power should subsidize navigation. The undertaking on the section of the river entirely in Canada is therefore a commercial project and the United States does not need to contribute toward the cost on this section.

Thomas H. Hogg, hydraulic engineer, Hydro-Electric Power Commission of Ontario, Toronto, the only Canadian engineer who found it convenient to participate, took exception to the assumption that water power should be charged with the cost of navigation development on the St. Lawrence River. He said:

"There are two conditions under which a possible justification of this assumption might be considered, and these are: First, that the development of water power caused existing navigation structures and channels to become inoperative; second that the benefits derived from the power developed were shared by districts and interests identical with those benefited by the navigation works.

"Present conditions on the St. Lawrence River provide for navigation with a draft of 14 ft. and the proposal dealt with by the author is for deep-draft navigation. It would be under certain circumstances, perhaps, reasonable for power developments on the river, if they destroyed existing works, to be charged with facilities equivalent to those existing, but it is quite unreasonable to expect a power development to go beyond the existing facilities and pay the whole enormous increased cost occasioned by the construction of improved river channels, canals and locks suitable for vessels six or eight times as large as those now accommodated by the existing canals.

Navigation Benefits

"At the present time power is transmitted to points about 250 miles distant from generating stations, so that potential developments are of possible value throughout a circle described by a radius of this length with its center at the site of the development. On the other hand, navigation benefits of the particular instance being considered extend far beyond this radius of 250 miles, and in fact reach their utmost value in a district greatly removed from the locality of the power development. The districts that would be especially benefited by the construction of deep-draft navigation works on the St. Lawrence River are the eastern portion of the prairie provinces in Canada and the Central States.

"The conclusion to be reached then is that, according to the author's assumption, industry and other power users in the district bounded by Toronto, North Bay, Quebec, Boston and Rochester, should alone pay all the cost of these navigation works which would benefit primarily the district west and southwest of Detroit.

"An analysis of these economic aspects of water-power development aided by a special census in the United States shows that of the whole investment in a water power and the industries built up by it, only 13.4 per cent is found in the water-power development and 86.6 per cent in the applications of the power. In the matter of employees less than 3 per cent of these are engaged in the production of power and over 97 per cent in industries utilizing that power. The wages paid are 2.3 per cent of the total for water power, and 97.7 per cent of the total in application of this power.

"Great and widespread benefits are received by all people and interests in the district affected by the production of power through the application of

that power to industry; but the benefit derived from the power per se is usually small—accounting as it does in its tolls for less than 3 per cent of the business of the district. Thus, power development is in the same category as navigation works, and instead of being forced to pay tribute, water power more fairly might be subsidized."

H. deB. Parsons, consulting engineer, of New York City, was of the opinion that a large proportion of the material written and spoken about the St. Lawrence project had been propaganda and designed to awaken popular fancy. The canalization of the St. Lawrence and of the rivers joining the Great Lakes, coupled with hydraulic power development, was such a gigantic undertaking that the problem required intensive study based on facts, before any sound opinion could be reached. The engineering difficulty of damming an immense river, situated in a cold climate and not having a low-water period to facilitate cofferdam construction, was not the sole problem. A greater difficulty was the one of correctly conceiving future conditions of finance and trade, that the completed project might be of greatest national benefit without excessive cost.

An International Commission Recommended

With so many vital questions to be settled, the speaker believed that both governments should unite in the appointment of an international commission composed of the highest-grade engineers, which should outline its recommendations in interim reports, these reports to be published so that constructive criticism might be received. When its final report was accepted and an agreement between the governments reached, then the works could be started, and there would be no reason why part should not be done by the governments and part by private interests, should such a division be deemed the most economical and quickest procedure.

Prof. H. C. Sadler, of the University of Michigan, discussed the subject from the standpoint of ships and their operation. His conclusions were that there was nothing to hinder existing seagoing vessels up to 7,500 tons dead weight from utilizing the proposed St. Lawrence route to reach the great productive Middle West of this continent.

L. B. Sabin, general superintendent of St. Mary's Falls Canal, said that if the St. Lawrence improvements were for the sole purpose of navigation, it was doubtful whether its cost could be justified even with the advantage of its connection with lanes of commerce already established over which traffic is hauled at a cost hardly approached by any other system of transportation except the ocean.

Fortunately, it is not merely, and perhaps not mainly, a navigation matter. The value of the water power is such that whenever the large blocks of power developable can be sold advantageously, the returns should pay interest on the entire cost, and in a term of years amortize the investment as well. Having in view particularly the needs of navigation, the speaker felt that its requirements have been made subordinate to those of power; that an increase in prime water in the paper was given more weight than better continuous navigation depths.

Gardner S. Williams, consulting engineer, Ann Arbor, Mich., was of the impression that all the power that could be obtained from the water in this project would be absorbed as soon as it could be made available. Reports from the superpower zone in the East showed that the district included would take by 1930 a total of 3,200,000 electrical horsepower, the increase in steam generated power from 1920 to 1930 amounting to 1,920,000 hp. The development of this power would be a source of revenue to Canada and subsidiary interests in this country.

Estimated Costs

Mr. Williams agreed that the estimates for this project probably were inaccurate. The cost of this development would be nearer $600,000,000 than $500,000,000 and that was twice as much as the last report in the projects indicated.

Next to the St. Lawrence project, said the speaker, there has been much misinformation on the results of Chicago diversion. In a treaty between Great Britain and the United States Canada had been allowed 16,000 sec.-ft. more from Niagara than this country to compensate for the 10,000 sec.-ft. diversion at Chicago. In addition Canada was diverting in other ways twice as much water as before the war, so that it would be in the interests of fair play to give these things some consideration when complaining against Chicago.

The Law and the Blowoff Pipe

By A. L. H. Street

Where there is a likelihood that someone may be within range, it is actionable negligence to discharge steam through a blowoff pipe without safeguarding those within range. Failure to take such precaution gave rise to the case of Ambroz vs. Cedar Rapids Electric Light & Power Co., 131 Iowa Reports, 336.

Defendant's power house was in a manufacturing district. A blowoff pipe had its exit near the edge of a small lake at the rear of the plant. For years men and boys had fished from the shore at this place, and the plaintiff, while so engaged, was severely injured through being struck in the back by a blast of steam from the pipe. The Iowa Supreme Court affirmed judgment in his favor for damages.

Responding to the defendant's claim that the plaintiff was a trespasser, the court said:

"It does not appear that defendant had title to the soil at the place of the accident, and the mere fact that it had built out the shore of the lake at this point by depositing cinders, and was making use of the land thus built out . . . would not, as it seems to us, render it unlawful for persons to go along the shore of the lake for purposes not involving any interference with such use of the made land by defendant as it was making in connection with its plant. . . .

"However this may be, the [trial] court submitted the case to the jury on the theory that if they found defendant, through its agents and employees knew that men and boys were frequently, during the fishing season, engaged in fishing at the rear of the works and in the vicinity of the place where blowoff pipe of defendant discharged, and knew that such persons were likely to be in the vicinity of the end of the pipe at any time during the day, and, notwithstanding such knowledge, without warning violently blew off the steam from its boilers through such pipe, thereby injuring the plaintiff, and that this act of blowing off steam without warning was in wanton disregard of the safety of persons whom defendant had reason to believe might be in the vicinity—then they were to determine whether or not the defendant was negligent in causing the discharge of steam which injured the plaintiff without giving him warning. No objection is made to this instruction, and we think that it eliminates any question as to whether or not plaintiff was technically a trespasser, for even as to trespassers the defendant was charged with the duty of not wantonly disregarding their safety if it had reason to believe that they would be placed in danger by any action on its part. . . . Even as to persons technically trespassers, a landowner is liable for permitting dangers to exist unguarded where persons are in the habit of coming if he knows that they are likely to be injured thereby. . . . But to constitute the wantonness or indifference which will render the act causing the injury negligent as to such persons, it is not necessary that there be a design or intention to do injury. . . .

"To constitute wantonness or indifference to the safety of persons who might reasonably be expected to be in a position where they would be injured by the sudden discharge of steam from the blowoff pipe, it was not necessary that defendant should have known of the presence of the particular person injured, but it was sufficient if it had knowledge that persons were likely to be in a position to be injured if the steam was thus discharged without warning."

As to the question whether the plaintiff was guilty of such contributory negligence as barred recovery of damages, the Supreme Court decided that the mere fact that he knew or might reasonably be expected to know of the existence of the pipe by its projection from the bank would not charge him with knowledge that it might be used in such a way as to imperil his safety. The blowoff was not used oftener than twice each day, and plaintiff had never before been in the locality. He was not warned in any way as to the use to which the pipe might be put, or that the place in front of the opening of the pipe was a dangerous place. It is to be inferred that if he had known that steam was likely to be blown off any time, his placing himself in front of the pipe would have been such contributory negligence as would have precluded recovery of damages.

Comparative Tests of Heating Systems*

ALTHOUGH thermostatic control appears to be superior to manual operation for individual radiators, and the use of the unit thermostatic control in large buildings has been satisfactory in certain conditions, it appears that manual control for the heating system of an entire building from one central point offers greater practical possibilities with regard to both economy and ease of operation. Tests of a hot-water system utilizing varying temperatures by heating the water with steam proved it more economical than the usual steam system. Comparison of the atmospheric trap and ordinary atmospheric systems indicated that the former gave better results.

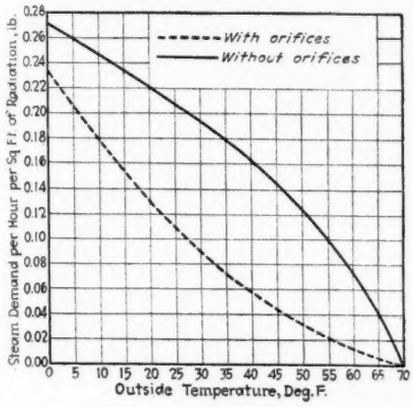


Fig. 1—Unit steam demand for orifice system lower than average

One of the simplest types of thermostatic control is that in which the steam supply for an entire building is operated by a single thermostat. A desirable feature is that a time attachment is possible for maintaining a reduced temperature at night. It is easy to conceive conditions, however, under which satisfactory control might be difficult. Where there are a large number of rooms, control or regulation is a more complex matter.

Intermediate Type Thermostats Superior to Positive

Thermostats of the positive type, which either open the steam valve wide or maintain it tightly closed, have proven inferior to those of the intermediate type. which open the radiator valve to the degree conforming more nearly with required radiation. The positive type has been improved by adding orifice sleeves to radiators, so that the flow of steam is throttled considerably, making a longer operating time element and giving in actual practice less fluctuation in room temperature by a matter of three or four degrees.

In comparing manual adjustment of individual regulators with individual thermostatic control, it developed in tests that the latter showed savings which increased as outside temperatures moderated. On the other hand, as the outside temperature approached zero or went below, the saving with thermostatic control over hand control became unimportant. One objection found was the high cost of upkeep of individual thermostats, which resulted largely from tenants tampering with the apparatus.

A saving of 16 per cent in steam used per year for 1,000 cu.ft. of space by thermostatic control of individual radiators over hand control was demonstrated in tests on two similar buildings for short hour heating.

PERFORMANCE OF THREE TYPES OF SYSTEMS COMPARED

Type	Number Buildings	Required Radiation, Sq.Ft.	Season's Condensate, 1,000 Lb.	Cond. per Sq.Ft. Radiation	Temperature Condensate, Deg. F.
One pipe	143	280,658	142,533	508	150
Atmospheric Trap	59	165,596	68,198	412	130
Atmospheric	79	135,246*	58,294	430	170

*Under required radiation for atmospheric systems the additional 25 per cent installed for safety was not included. The figures are equivalent to direct radiation.

An investigation of thermostatic control from a central point in twelve large buildings led to the conclusion that while four of these experienced a loss by the application of this principle, eight received material benefit, which resulted from a combination of greater care and attention to the heating system than was the former practice. It is believed that unit thermostatic control on direct heating systems is a great advantage.

In some buildings this is worth while, and in others it has been a complete failure. The latter result is ordinarily due to tampering with the apparatus by the tenant or to insufficient supervision.

Manual control of the heating system from a central point, so that just sufficient steam is supplied to meet the requirements of radiation, ordinarily prevents tenants from opening windows and also from wasting heat in other ways. The cooling and warming up period may thus be regulated for economical results. This system requires some attention by the engineer or superintendent who ordinarily is rushed with other matters and may find it difficult to give proper attention to regulation of the heating system.

Automatic Control from a Central Point

Automatic control from a central point has been to some extent obtained by a device recently placed in commercial operation, which turns the steam on and off at predetermined intervals. The period of this change can be varied according to outside temperature. Tests of this system are now in progress.

Centralized control by means of the fixed orifice method, while not new in principle, has recently been more widely commercialized and possesses many attractive points.

In this system the pressure at the point of supply is varied in accordance with the requirements of outside temperature. An orifice placed at the supply point may be utilized as a flow meter, so that the pressure admitted by hand throttling is determined from outside conditions. Steam is distributed to the heating coils by risers and orifices, so that no steam regulation except that at the central point, is required. A system of this kind was described in the Oct. 2, 1923, issue of *Power*.

A minimum of manipulation is required, and the principle may be readily adapted to old systems of any type, with either steam or hot-water radiation. Rooms requiring more heat can be supplied by changing the radiator orifice accordingly. New systems of any type can be installed cheaply by merely replacing the ordinary radiator valve with an orifice and properly proportioning the pipe sizes and orifices. Initial and maintenance costs are low as compared to other types of systems.

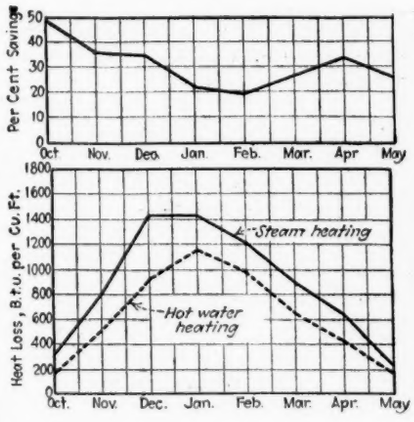

Per Cent Saving
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May
Heat Loss, B.t.u. per Cu. Ft.
Steam heating
Hot water heating
Oct. Nov. Dec. Jan. Feb. Mar. Apr. May

Fig. 2—Hot-water heating more economical

Total radiation losses compared below and per cent savings given above.

The results of tests indicated a marked saving due to orifice control. The system tried out was in the office floor of one of the central heating plants in Detroit. This was a one-pipe up-feed system serving only one floor and containing about 545 sq.ft. of radiation. The pressure ahead of the metering orifice at the point of control was maintained just sufficient to secure 70 deg. building temperature.

Aside from any saving effected by this installation, the increased comfort of the building was marked. The inside temperature seldom varied more than two degree during the day, with only about two or three adjustments of the throttle valve. The usual stuffy feeling of the air was entirely eliminated. The steam consumption during the period

*Abstract of report of the Heat Utilization Committee, given at the last convention of the National District Heating Association.

with the orifices in the system was 55 lb. per day per degree difference in temperature, while with the straight steam system the unit consumption was 83 lb., indicating a saving of 34 per cent.

Why the Tests Were Run

The tests were run mainly to determine the practical disadvantages rather than quantitative savings. However, if the savings were cut in half they would still be worth striving for. Fig. 1 shows the steam demand per square foot of radiation based on outside temperature as obtained with this system, compared with that representing the average of thirty buildings operating with various other types of heating systems.

The radiation of the rooms under test was figured by the method described by the National District Heating Association, but did not appear to be excessive in cold weather. Most of the other buildings used in comparison were modern buildings in which radiation was figured by competent heating engineers.

With hot-water heating the thermal output of the entire system can be controlled so as to equal the heat loss from the building and keep the radiation sufficiently warm at all times. This is accomplished by changing the temperature of the circulating water according to outside temperature. It has an advantage, in that by heating the water with steam, a greater percentage of the B.t.u. content may be utilized than if steam were applied directly.

Two Systems Compared

The heating requirements for steam and hot-water systems in two hotels of similar location, construction and exposure, having inside volumes of 10,500,000 cu.ft. and 12,387,300 cu.ft. respectively, are shown in Fig. 2. Hot water was utilized in the building with the larger volume. It was found that the heat consumption by hot water was 50 per cent less in mild weather and only about 20 per cent less in cold weather, as also shown in Fig. 2, indicating, as usual, the well-known waste by steam systems at higher outside temperatures.

In comparing the one pipe, atmospheric trap and atmospheric system, 333 installations were at first considered. Some of these buildings were known to have little or no regulation, and these were afterward eliminated from results. Average quantities are given in the table.

The atmospheric trap system, which contained an expansion trap at the outlet of the radiator, showed the lowest rate of condensation per square foot of radiation and the lowest average temperature of the condensate as discharged to the sewer. It is, therefore, considered to be the most economical of these systems for general conditions.

The atmospheric system is a two-pipe system where the supply enters the top of the radiator through a graduated valve. The return is open to the atmosphere. In order to keep the returns condensed, 25 per cent is added to the surface of the radiator. Atmospheric systems have proved satisfactory but depend largely on the tenants, as those who do not pay steam bills directly, cause waste of steam by opening windows, etc. By installing traps, radiation and temperature of the condensate to the sewer have been greatly reduced.

Welded Piping in Buildings*

By H. E. Wetzell

Only recently has it become common practice to weld building piping. The passive interest heretofore shown by the authorities in the welded pipe joint was probably due, in large measure, to lack of complete information on the subject. One engineer, for instance, thought a branch was welded to a main line by cutting a hole in the main large enough to permit entrance of the branch, which was then welded in without knowing its amount of projection into and consequent obstruction of the main.

The actual procedure in making a branch connection is to shape out the end of the branch pipe with a cutting blowpipe, so that it will fit the contour of the main. Then the branch is butted up to the main, and the latter marked by chalking around the circumference of the branch. Next a hole is cut in the main inside of the chalked circle, but equal in diameter to the inside of the branch. Finally, both the hole in the main line and the end of the branch are beveled, fitted and welded, giving the equivalent, as far as internal pipe friction goes, of a cast fitting.

The welded joint is stronger than any of the types of threaded joint. Installation time and expense are saved when piping is welded. Incidentally, the use of the oxyacetylene process for this work obviates the necessity of a detailed piping layout and that of using a specifically marked length for a certain location.

Instead the piping may be carried to the place of installation and there cut and fitted to the job. The errors of the layout draftsman and pipe cutter are eliminated. Short ends of piping may be utilized. All the thread cutting, leading, packing and calking, which add greatly to the cost of a screwed or flanged piping job, are avoided.

The direction of run of the pipe line can be altered at will. It is merely necessary to cut butting ends to the desired angle with the blowpipe and then weld them together. Special fittings are unnecessary. In fact, no fittings are necessary other than valves, and those which can be readily fabricated on the job from the pipe itself.

Corrosion at threaded joints, and leakage at gaskets or the threads of flange connections are avoided when pipe joints are welded. Piping alterations are easily handled by the oxyacetylene process.

Other advantages of welded piping systems are good appearance and ease of insulating, no flange covers being necessary.

*Abstract of an article in the September, 1924 issue of the Journal of the American Welding Society.

Use of Blast-Furnace Gas*

By Dr. Rudolf Herzfeld

Although the last decade has witnessed a considerable increase in the utilization of blast-furnace gases, they are still very far from being employed to their fullest advantage.

In most iron plants the gas from the blast furnaces is used to heat the air for the blower, and the excess, after a superficial cleaning, to heat steam boilers. A most important step has been the installation of gas engines instead of steam to drive the blowers. This makes it possible to cut the consumption of gas for the blower system by about 30 per cent.

If the 70,000 cu.ft. of gas obtained per ton of iron produced in the blast furnace, after deduction of 64,000 cu.ft. used for heating, etc., is employed to drive gas engines in the steel mill, a remarkable efficiency results. In the case of the British steel works this gas power would not only drive all the machinery, but would be 800,000 hp. in excess of requirements, or four times the steel mine requirements.

In spite of its advantages as enumerated, it will hardly be possible to utilize the gas fully, because in most countries crude iron and steel products are frequently produced in entirely separate plants, so that the cheap power is not available for the steel plant. But even where steel and iron works are combined, there are several causes that prevent the introduction of such a modern system.

If the blast-furnace gas is to be fully utilized with all the modern and essential machinery required, it means that the entire plant machinery with the exception of the blowers would have to be electrically driven. The steel industries do not feel equal to this immense change of system, partly because of the labor question. Then, too, the steam industry is fighting for its foothold in the steel industry, as shown by the turbine blowers, which utilize the exhaust steam from the rolling mills.

It is only in very exceptional cases that such an installation would prove economical in operation, and in most cases, where exhaust steam is not sufficient to furnish the entire power required, gas engines are far superior. Moreover, in modern plants, the considerable excess gas can be used for sources of heat, as for instance, in the steel mixers or to supply electro-steel furnaces with current.

Kentucky River Development Plans.—M. Webb Offutt, W. J. Loughridge, R. T. Green and W. A. Heffner, of Lexington, Ky., have filed application for preliminary permits covering the erection of power plants at each of the government locks from No. 8 to No. 14, inclusive, on the Kentucky River.

The application applying to the government dams is in direct conflict with that filed Sept. 29 by the Kentucky Hydro-Electric Co.

*Extracted from Zeitschrift Industrie und Tecknik.

Suggest That Coal and Oil Industries Unite To Eliminate Over-Production

Wastes in Both Industries Caused by Over-Production and Competition Is Thought

TO BRING to all branches of the coal trade a keen realization of the proportions of oil competition is one of the crying needs of the day, in the opinion of those deeply interested in the welfare of this industry. The conditions that brought about the production of 730,000,000 bbl. of petroleum in 1923 are thoroughly unsatisfactory to the oil industry.

Those who are studying the effect of oil competition on coal are convinced that the coal industry itself does not have a clear realization of the extent of the inroads being made. The Standard Oil Co. just at this time is boasting in newspaper advertising that oil now is the chief source of power in the United States. The inference is that it definitely has displaced coal from the head of the list. An analysis of the situation indicates that the claim of the Standard Oil Co. is not justified, but it also shows that while coal probably still is in first place, the margin between it and oil is a narrow one. By narrowing the comparison to power, exclusive from heat, it is necessary to include gasoline as well as fuel oil in the calculation.

The 730,000,000 bbl. of petroleum produced last year are equivalent to 200,000,000 tons of coal. The 1923 output of bituminous and anthracite coal combined was 657,000,000 tons, so that at first glance the ratio of coal to oil still would seem to be 3½ to 1 even on a B.t.u. basis. Out of the 657,000,000 tons of coal, however, a considerable deduction must be made, since a part of it is not used in power production. In round numbers these deductions would be about 296,000,000 tons, which leaves a balance used for power of not more than 360,000,000 tons. This would seem to indicate that coal still had a lead of almost two to one over oil, even when power uses only are considered. However, consideration must be given to the fact that more power is squeezed out of oil than is produced from coal.

When allowance is made, the superior efficiency of gas engines over steam engines in getting power units out of fuel units a considerable part of the lead of coal is overcome. Since no accurate calculations have been made of the average efficiency of steam plants, only approximations can be used. In all probability an assumption of 7 per cent of the average thermal efficiency of the coal-burning power producing equipment is high. A corresponding assumption of 10 per cent for the petroleum-using power-producing equipment (including gasoline engines) probably is low. The coal industry then will be willing to accept the following equations:

360,000,000 × 7 per cent = 25,200,000.
200,000,000 × 10 per cent = 20,000,000.

Now the comparison has shrunk to proportions of 25,200,000 for coal to 20,000,000 for oil. Under the most favorable conditions this is all the lead that coal has as a power producer. The petroleum industry, of course, will insist that steam efficiency is less than 7 per cent and would raise the 10 per cent assumed for petroleum products.

While this calculation is rough, it serves to point out the extraordinary inroads that oil has made in the field of power production. Any frank appraisal of the situation leads to the conclusion that coal must join hands with oil in a determined effort to eliminate the wastes of over-production.

Standardizing the Return Tubular Boilers

Acting upon the suggestion of the United States Department of Commerce, the American Boiler Manufacturers' Association is now at work standardizing and simplifying the construction of the return-tubular boiler to be built in accordance with the A.S.M.E. boiler code. Standardization will not be limited to the pressure vessel alone, but will be carried into the setting and the fixtures. There will be uniform sizes, diameters and lengths; uniformity in the joints and tubes; a definite number of stays and braces; uniformity in the size, type and location of nozzles and all other openings into the boiler; definite grate areas for specific sizes; standard stack plate openings; uniform heights in the setting and in the method of boiler support, and of prime importance a consistent method of rating.

In other words a master design is being developed, to be known as the A.B.M.A. standard, which all manufacturers belonging to the Association will follow. Benefit to the trade will result in a reduction in the number of sizes, decreasing stocks and inventories, increasing turnover and expediting delivery, as it will be possible to go into quantity production. The architect and engineer will have for their selection a product of approved design and definite dimensions, and the purchaser will receive better value for his money.

In pursuance of this plan the Return Tubular Boiler Division of the Association met in Chicago on Oct. 29. Representative boiler manufacturers, with E. C. Fisher, of the Wickes Boiler Co., as chairman, were in attendance, sitting in with the committee to give and receive suggestions and eventually agreeing upon a uniform plan. The work of the day was limited principally to the pressure vessel. There will be other sessions on the setting and fixtures and eventually the final results will be presented to the association for adoption. Co-operating with the Department of Commerce, the effort then will be to have every state in the Union adopt the A.B.M.A. standard, with no individual restrictions or requirements, the ultimate aim being a uniform product for the entire country.

Delaware River Commission Working on Treaty

The Delaware River Treaty Commission is holding a series of conferences with the commissions representing the States of New York, New Jersey and Pennsylvania and representatives of the federal government together with their engineers, experts, etc., with the idea of arranging the treaty. Another conference will be held in Atlantic City about the middle of November, after which something definite may be announced.

Power Show To Feature Lectures

The Third National Exposition of Power and Mechanical Engineering, which is to be held at the Grand Central Palace, New York City, from Dec. 1 to 6 will, beside the exposition proper, feature a series of lectures on recent developments in important phases of power plant and mechanical engineering practices.

Lectures will be given by outstanding men on the following subjects: The boiler room, steam prime movers, oil and gas engines, hydro-electric power plant equipment, materials handling, modern machine tool developments, mechanical power transmission, mechanical refrigeration, heating and ventilating. These lectures will not conflict with the technical sessions of the annual meeting of The American Society of Mechanical Engineers, which will be held in the Engineering Societies Bldg., 29 West 39th St., Dec. 1-4, or the meeting of the American Society of Refrigerating Engineers which will be held Dec. 2-4 at the Hotel Astor.

Colorado Can Supply Coal To U. S. for 800 Years

Statistics for the year 1923, it is stated, show that the workable area of commercial coal in Colorado covered 19,754 sq. miles; 276 mines, with a total production of 10,336,735 tons. Coal authorities estimate the state's coal deposits at over 500,000,000,000 tons. Figured on the present rate of coal production there is enough coal in Colorado to supply the entire United States for 800 years.

Chicago Authorities Thought Amenable to Less Diversion

Officials interested in the development of the St. Lawrence quite generally have come to the opinion that it is useless to discuss the matter with Canada until an agreement is reached between the federal government and the sanitary authorities at Chicago. This domestic difficulty must be ironed out before any international progress is made, it is believed. The prospects of an agreement with Chicago are better at this time, it is stated, than ever before. There has been a decided change of attitude on the part of the sanitary authorities.

While the situation will be influenced unquestionably by the pronouncement of the Supreme Court of the United States when it hands down its decision in the diversion case, there is a feeling that an agreement that would reduce by 2,000 or 3,000 sec.-ft. the volume of water now being diverted from Lake Michigan would be acceptable to Chicago. This would bring the total diversion to 5,000 or 5,500 sec.-ft. Were such an agreement effected, the United States then could propose some form of compensation for the slight damage that Canada could claim for this reduced diversion. It either could be used to offset the advantage which Canada enjoys at Niagara Falls or could be taken care of in some other way.

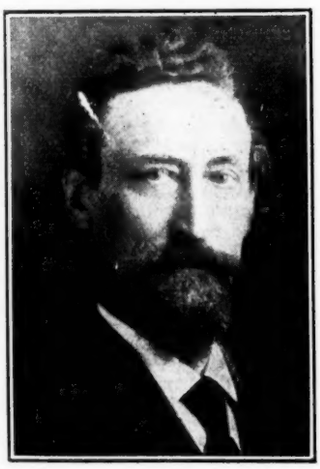
In addition to the encouragement which has come as a result of Chicago's more conciliatory attitude there are numerous indications of changing sentiment in Canada. The opposition to the St. Lawrence project is receding, apparently. The public in the Dominion has been impressed by the volume of business passing through the existing canals and by this year's freight congestion. Also financial plans for the St. Lawrence development have been worked out to the point where it is apparent that no appropriations in money from the treasuries of either country will be necessary. One plan is to extend governmental credit through the issue of special bonds. The plants, when completed, could be leased for operation at an annual amount not less than the current commercial interest rate on the moneys invested. The difference between this rate and the interest paid by the governments could be used to retire the bonds.

There has been a marked change in the outlook, it is declared. A month ago officials were inclined to view the situation pessimistically. Certain elements in evidence then led to the fear that the project was faced with a long period of international conversations. The assurances of the last week, however, have done much to dispel that gloomy outlook, and the prospects of the development, it was stated in a high official quarter, are better today than ever before.

Dr. Nordberg Dies at Sixty-seven

On October 30, the passing of Dr. Bruno V. Nordberg, founder of the Nordberg Manufacturing Co., of Milwaukee, brought to a close a career which had for forty years been of unusual interest to the power industry and which is a real loss to the engineering world.

Dr. Nordberg as a steam engineer stood pre-eminent in the period in which he lived, and his unusual skill,



Bruno V. Nordberg

inventive genius and engineering foresight are shown in special installations throughout the country.

Born in Finland in 1857, the son of a sea captain, he early in life showed an aptitude for science and engineering and entered the University of Helsingfors, from which he graduated in 1878. Believing that America offered greater possibilities than the old world in his chosen field, he came to this country in 1880, where he found employment with the E. P. Allis Co. One of his first duties was to assist in the design of two large vertical blowing engines; later, these engines were turned over to him for completion. One of them is still used for blast-furnace blowing by a prominent steel company.

Constantly endeavoring to improve the efficiency of existing designs that would permit of higher economies, Dr. Nordberg early recognized the possibilities of the poppet valve when used in connection with the steam engine, also the opportunity for improving the efficiency of the slide-valve steam engine by providing a better control of steam admission, which resulted in his designing for engines of this type a poppet-valve governor that permitted an economy considered impossible at that time. In later years this type became still more desirable in order to utilize the high steam pressures and superheats of modern steam practice. It is now used on the Nordberg unaflow engine.

In 1886 the Bruno V. Nordberg Co. was organized for the manufacture of governors, and in 1890 the name of the company was changed to the Nordberg Manufacturing Co. It was at this time that the first Nordberg steam engine was built, which was of the poppet-valve type and is in service today. About this period a demand for mining equipment developed and as this special machinery was particularly adapted to the genius of Dr. Nordberg, he soon turned his attention to steam hoists, engines, compressors, steam stamps, condensers, etc. Around 1900 larger quarters were needed and the present plant, covering forty-two acres, was built.

Dr. Nordberg designed many special steam hoists and unusual hoists for air and electric operation and built some of the largest air compressors and Diesel engines that are in service at the present time.

He was a member of the A.S.M.E. and other engineering societies in this country and abroad. The degree of Doctor of Engineering was conferred on him by the University of Michigan in 1923 in recognition of his skill in the design of special machinery. During the latter years (around 1914) of his life he built up his engineering staff by additions of authorities on Diesel engines, etc., from this country and Europe and imparted to them the valuable technical knowledge that he had acquired during his long years of study and research.

Power-Fish Controversy Nearing Agreement

After extended conferences in the West with all interests concerned with the fish problem in streams where power development is contemplated, Col. William Kelly, chief engineer of the Federal Power Commission, is convinced that power development can proceed without detriment to commercial or sport fishing. Moreover, he found each party to the controversy in a more conciliatory frame of mind than has been the case heretofore, with most interests entirely disposed to be reasonable.

The evolution in the salmon industry which has been brought about by the establishment of hatcheries on the lower stretches of the streams is confining commercial fishing largely to points below power sites. In the case of the Columbia, Indians on the upper river rely importantly on the fish resources of the stream for their own sustenance, but the volume of the run above Priest Rapids is such that Colonel Kelly believes no difficulty will be experienced in passing the fish over the proposed dam of the Washington Irrigation & Development Co. by means

of a series of resting pools. Physical conditions at the dam site lend themselves to the resting-pool method of getting the fish past the obstruction. It happens that the fish runs are during high-water periods on the Columbia. The question largely resolves itself into one of cost.

Dix River Development Nearing Completion

According to recent press reports the huge Dix River dam of the Kentucky Hydro-Electric Co., the largest water-power project in Kentucky, will be completed by Jan. 1. Contracts have been made to furnish power to public utility companies of Louisville, Lexington, Danville and other Kentucky cities. The Louisville Gas & Electric Co. has contracted for 15,000,000 hp. annually for a term of years.

Sigma Xi to Hold Meeting Devoted to Research

To bring scientists and engineers of all kinds together and to promote research, the Society of Sigma Xi will hold a dinner at 245 Madison Ave., New York City, on Nov. 17. The speakers will include Dr. Vernon Kellogg, secretary of the National Research Council; Dr. E. L. Thorndike, professor of psychology, Columbia; Dr. F. B. Jewett, vice-president, Western Electric Co.; Dr. Francis Carter Wood, director of cancer research, Croaker Laboratory; Dr. Michael Pupin, professor of electromechanics, Columbia. Further details can be secured from Prof. Walter H. Eddy, Teachers' College, Columbia University, New York City.

Los Angeles Power Bureau Improvement Plans

A seven-million dollar improvement program for increased substation and distribution facilities in industrial areas has been announced by the Bureau of Power and Light of the City of Los Angeles. This money is to be spent over a three-year period and will, it is estimated, provide for an additional 140,000 hp. by 1927. Work has already started on a new substation at Mateo and Hunter Sts., which will cost $200,000 and have a distributing capacity of 50,000 hp.

Included in the development program are the following improvements:

East Los Angeles, for substation facilities, enlarging and extending power lines, $960,000; Santa Fé-Southwest industrial area, general enlargements and extensions, $1,400,000; South Park industrial district, power-line enlargements and extensions, $1,100,000; San Fernando Valley, greatly increased facilities for heavy power service, $1,200,000; Florence Ave. and "Shoestring" district, extensions and improvements to heavy power service facilities to meet requirements of waterfront industries, $1,350,000.

All these added facilities are to care for the rapidly increasing industrial load on the municipal system, and they do not include extensions and betterments being made to meet growing power and lighting requirements of domestic and commercial consumers.

Ruth Falls Plant, Nova Scotia Equipment Plans

Ruth Falls, situated about two miles above tidewater, and the second power development on the East River, Sheet Harbor, County of Halifax, Province of Nova Scotia, will contain three units each of 3,000 hp. operating under a head of 109 ft. Initially, only two units will be installed, which will utilize 365 sec.-ft. continuous flow out of the final 500 sec.-ft.

The headworks is situated on a hill above the power house. The water is carried from the headworks by a pressure tunnel 12 ft. in diameter through solid rock to the base of the hill, a distance of 81 ft. vertically and 276 ft. horizontally. At the base of the hill three 6-ft. diameter steel penstocks will connect the tunnel with the three turbines. Two vertical, single-runner turbines will be supplied by the S. Morgan Smith Co., York, Pa. Each turbine will have a maximum capacity of 3,290 hp. at 400 r.p.m. and will be controlled by a Woodward governor. Each unit will be direct-connected to a 2,500-kva. alternator with direct-connected exciters, furnished by the Swedish General Electric Co., of Toronto.

The entire development has been designed by the engineering staff of the Nova Scotia Power Commission, of which K. H. Smith is the chief engineer, H. S. Johnson, hydraulic engineer, J. F. Lunsdun, electrical engineer and A. M. James, engineer of lands and rights.—*Canadian Engineer.*

Public Ownership Defeated on Pacific Coast

Resubmission by initiative in California of the Water and Power Act, the initiated measure known as the Bone bill, which was referred to the voters in the State of Washington, the proposed prohibition of power development on the Klamath River in north north California, also an initiated measure, and the gubernatorial election in Arizona all seem to point to rejection of public ownership of utilities in the far West.

Of these contests the most important was that in California over the Water and Power Act, which was designed to amend the state constitution so as to bond the state for half a million dollars for the purpose of launching state-wide public ownership program of water-power development. This measure was defeated on its first submission two years ago by two to one.

The Bone bill, second in importance, submitted to the voters in Washington, was intended to give cities and towns the right to purchase and sell electrical energy inside or outside their corporate limits and to acquire or construct electric generation transmission and distribution systems. This bill met with defeat in every county, and even in Seattle, which was the headquarters of the agitation and where it was argued that the bill would give a needed outlet for power from the Skagit municipal system, it was beaten by more than 6,000 votes.

The Klamath River bill, which was sponsored by the California Fish and Game Commission, to prohibit power developments for all time along virtually the entire length of the river, creating a fish and game district is reported as defeated.

The importance of the Arizona election to the power development industry lies in the part played in it by the seven-state treaty for the development of the Colorado River. This treaty, accepted by the United States government and by Colorado, California, Nevada, Utah, Wyoming and New Mexico, was rejected by Arizona under the leadership of Governor W. P. Hunt. Mr. Hunt ran for re-election as the candidate of the Democratic party, basing his campaign largely on his opposition to the treaty. As the paper goes to press, indications are that Governor Hunt is victorious.

Changes to Mercury Turbine Prevent Inspection

A joint statement has just been issued by the Hartford Electric Light Co. and the General Electric Co. regarding the Emmet Mercury Turbine Boiler installation made over a year ago for the Hartford Electric Light Co. in Hartford, Conn. This installation has attracted considerable attention, and the success achieved by it has been gratifying, but certain changes and improvements in details seem advisable. These changes are now being made. So many requests to inspect the installation have been made by those interested, and as it is not possible while these changes are going on to admit visitor, this notice is being issued so that disappointments will be avoided. When the equipment is again in operation, announcement will be made and facilities provided for inspection.

Dr. Ferranti Honored by Engineers

Dr. S. Z. De Ferranti, the well-known British engineer, was tendered a testimonial luncheon at the Yale Club, New York, last Thursday by the four Founder Engineering Societies. John W. Lieb presided and greetings were extended by Calvert Townley for the Electrical Engineers, Alex Dow for the Civil Engineers, J. V. W. Reynders for the Mining Engineers and F. R. Low for the Mechanical Engineers. Mr. Low traced some of the activities of Doctor Ferranti as a pioneer in the field of electrical distribution and referred pleasantly to a visit in which he had had an opportunity to view some of the Doctor's work.

In response to these greetings, Doctor Ferranti emphasized the common interest of the four branches of engineering represented, and then related some of his early experiences in developing an electric supply system for London, back in 1886. This was a series system supplying certain large buildings and clubs. It soon became apparent that it was not desirable to have the generating plants located within the district in which the current was consumed and that suitable sites with reference to fuel and water must be had. This involved the problem of transmission and the need for workable

transformers, and led to the development of the latter by Doctor Ferranti, as well as the introduction of the paper-covered cables. Moreover, there were practically no measuring instruments at that time, and the voltage on the high-tension system was measured by means of lamps in series, the brightness indicating the comparative increase or decrease in voltage. Another factor was the adaption of the existing types of engines to take care of a variable electrical load.

In conclusion the speaker expressed the opinion that the opportunity before us in the electrical field at present is infinitely greater than during the earlier period, although at the time he became engaged in electrical work he had been under the vague impression that little more was to be accomplished.

New Witbank Power Station Design Described

The president of the South African Institute of Engineers has recently given out the outline of the design of the Witbank power station in the Transval Province of South Africa, according to *The Engineer*.

The station site is about 5½ miles from the Oliphants River; a gravity dam is being built across the river to impound a maximum of 1,320 million gallons of water.

A pumping station is being incorporated into the dam to allow 2,360 gallons per minute, to be pumped against a static head of 627 ft., to a storage reservoir above the power station. The pipe line will be 15 in. in diameter, and from the reservoir the water will flow by gravity to the cooling pools.

The station is designed to accommodate five 20,000-kw. turbine generators. The first three turbines to be installed will be supplied by C. A. Parsons & Co., Ltd., of Newcastle-on-Tyne, and will be of the double-cylinder reaction type, running at 3,000 r.p.m. Each machine will be provided with two condensers with steam ejectors for removing air and the ordinary electrically-driven-centrifugal circulating pumps.

The turbines will be supplied with steam at about 250-lb. gage and at a temperature of 660 deg. F. The boiler house is being laid out to accommodate twenty Babcock & Wilcox marine type boilers fitted with chain grate stokers. The important particulars of the boilers are: Heating surface, 9,352 sq.ft.; superheating surface, 3,700 sq.ft.; economizer surface, 6.500 sq.ft.; grate area, 288 sq.ft.; normal capacity, 70,000 lb. of steam per hour.

The ash-handling plant is of particular interest. It consists of a tank in the ash basement in which a paddle wheel slowly revolves. The ashes are led into this tank by a chute that is sealed at the bottom, and as the ashes are slacked in the tank, they are slowly and continuously discharged by the paddle wheel onto a rubber conveyor belt, which takes them to a bunker, from which they are carried to the ash dump by endless haulage.

Current will be generated at 6,000 volts three-phase, and stepped up to 132,000 volts, the transformers and switch-gear being placed in an outdoor switchhouse. A transmission line carrying two circuits will convey the 132,000-volt current to Brakpan power station, a distance of approximately 65 miles, where it will be again transformed down to 40,000 and 20,000 volts, at which pressure it will be distributed through the existing networks of the Victoria Falls Power Company.

Water-Power Projects

The Northwestern Power & Manufacturing Co. was extended a preliminary permit covering a 9,000-hp. project on the Elwaha River in Washington by the Federal Power Commission at a recent meeting.

A preliminary permit in favor of Walter Cravens, of Kansas City, was authorized covering a power project on the Osage River in Missouri. The proposed development involves the construction of a dam 100 ft. high, forming a reservoir with an area of 100 square miles. The power capacity is 20,000 hp.

A preliminary permit was authorized for the Pringle Falls Electric Power & Water Co. of Portland, Ore., to cover a development on the Deschutes River. The capacity of the project is 3,000 hp.

Dell M. Potter, of Clifton, Ariz., was given a permit covering a 15,000-hp. project on the Black River in Arizona. It is proposed to construct five diversion dams in Black River and in its East and West forks.

In compliance with a special act of Congress the preliminary permit of the Dixie Power Co. was extended until Oct. 15, 1925. It will be recalled that this permit was the basis of a controversy between Walker Powell, of the Dixie Power Co., and Hugh L. Cooper, who was considering the development of the project with the idea of transmitting the power to St. Louis.

The permit of the Pacific Power & Light Co., of Portland, Ore., covering a project near the mouth of the Deschutes River, was extended until Oct. 10, 1925.

Personal Mention

Robertson Matthews has resigned his position as experimental engineer at the Navy Experimental Station, Hampton, Va., to accept a position with the Automotive Engineering Co., Manufacturers of oil engines, Montreal, Canada.

J. O. Marsh has been appointed chief engineer of the Los Angeles Board of Public Utilities, succeeding Fred A. Lorentz, resigned. Mr. Marsh has been office manager engineer of the California State Highway Commission at division headquarters in Los Angeles for the last seven years.

Society Affairs

The Meriden Section of the A.S.M.E. will hear James Hartness, president of American Engineering Council speak at its Nov. 17 meeting, on "The Engineer in Politics."

The Newcomen Society, for the study of the history of engineering and technology, South Kensington, London, will hold its annual general meeting on Nov. 12, at Caxton Hall, Westminster, S.W.1.

The Fort Wayne, Ind., Section of the A.I.E.E. will make an inspection trip to the Spy Run Power plant of the Indiana Service Corp. on Nov. 20.

The Third Paper Industries Exposition has deferred its exposition, which was to have been held in 1925 at the Grand Central Palace, New York City, until 1926.

The Atlanta Section of the A.S.M.E. will hold its Nov. 20 meeting at the Chamber of Commerce Bldg. The subject will be "The Engineer and the Contract Law," and the speaker, R. B. Troutman, attorney.

The Lehigh Valley Section of the A.S.M.E will hold a meeting on Nov. 28. "Pulverized Coal" will be the subject, and the speakers will be H. G. Barnhurst and C. H. Frick.

The Metropolitan Section of the A.S.M.E. will hear representatives of the four national societies speak on "The World Power Conference," at its Nov. 20 meeting, which will be held at the Engineering Societies Bldg., New York City.

The Lehigh Valley Section of the A.I.E.E. will have as the attraction for its Nov. 21 meeting, a paper by N. G. Renicker, of the Pennsylvania Power & Light Co., on "The Development of Power." This meeting will be held at the Schuylkill Country Club, Pottsville.

The A.S.M.E. Program and Papers Committee announces some changes in titles of papers on the program for the annual meeting, which is to be held in New York City, Dec. 1-4. An additional paper scheduled for Wednesday afternoon, "Direct Measurement of the Heat Content of Superheated Steam," by Walter S. Osborne, Bureau of Standards, has been added to the Steam Tables Research Section program.

The American Society of Refrigerating Engineers and **The American Engineering Standards Committee**, who are sponsoring the Mechanical Refrigeration Safety Code, announce a public hearing at 2 p.m., Dec. 1, at the Engineering Societies Building, 29 West 39th St., in Room 1001, which will probably be the last public hearing for this code. Those interested are urged to attend the hearing.

The American Society of Heating & Ventilating Engineers' nomination committee has announced its selection of officers for 1925, as follows: L. A. Harding, president; William H. Driscoll, first vice-president; F. Paul Anderson, second vice-president; Perry West, treasurer; Homer Addams, Willis H. Carrier, Joseph A. Cutler, Walter E. Gillham, W. T. Jones, Thornton Lewis, J. H. Walker, A. C. Willard, members of the Council. Nominated by the Council for membership on the Research Committee: William H. Driscoll; H. M. Hart; C. V. Haynes, J. I. Lyle; Perry West; W. S. Timmis to serve the unexpired term of E. E. McNair, resigned.

Business Notes

The Northern Equipment Co., Erie, Pa., manufacturer of Copes boiler feedwater regulators, has appointed E. L. Bowers as advertising manager.

The Electric Machinery Mfg. Co., Minneapolis, Minn., has opened a direct factory sales office at St. Louis which will be in charge of R. H. Olson. It will be in the Railway Exchange Bldg., 611 Olive St., St. Louis, Mo.

The General Electric Co., Schenectady, N. Y. announces that Robert Miller, manager of the Salt Lake City sales office, has been appointed acting manager of the Rocky Mountain district in the absence of H. D. Randall on account of ill health.

The Roller-Smith Co., 233 Broadway, New York City, announces the appointment of Charles R. Speaker, Evening Star Bldg., Washington, D. C., as its representative in the District of Columbia. He will also handle the company's government business in Maryland, Virginia and North and South Carolina.

The Quigley Furnace Specialties Co., 26 Cortlandt St., New York City announces that A. A. Hutchinson, former manager of the Eastern Coal and Export Co., and more recently president of the Hutchinson Engineering Co. of Birmingham, Ala., has joined the Quigley service, with headquarters in Atlanta, Ga.

The Combustion Engineering Corp., Detroit, Mich., announces changes: James Cleary, formerly manager of its Philadelphia office, will assume management in the Detroit and Cleveland territories with headquarters in Detroit; Frank Henderson will continue in charge of the Cleveland office; Joseph Lappin, formerly in charge of the Detroit office, has been assigned to New York for special work; the Detroit office has been removed from the Penobscot Bldg. to the Book Bldg., 1227 Washington Boulevard.

Trade Catalogs

Valves—Steere Engineering Co., Detroit, Mich. Leaflet describing the three-way backrun valve manufactured by this company.

Stokers, Mechanical—Stoker Manufacturers Association, W. V. McAllister, secretary, foot of Walker St., Detroit, Mich. The Condensed Catalog of Mechanical Stokers is a complete catalog of the various manufacturers of mechanical stokers and is an example of co-operative advertising for competitive companies. Twelve companies are here advertising chain-grate stokers, underfeed stokers and overfeed stokers: American Engineering Co., Philadelphia; Babcock & Wilcox Co., 85 Liberty St., New York City; Burke Furnace Co., 320 East North Water St., Chicago; Combustion Engineering Corp., Broad St., New York City; Detroit Stoker Co., 458 General Motors Bldg., Detroit; Green Engineering Co., First National Bank Bldg., Chicago; Illinois Stoker Co., Alton, Ill.; Laclede Stoker Co., St. Louis, Mo.; Sanford Riley Stoker Co., Worcester, Mass.; B. F. Sturtevant Co., Hyde Park, Boston, Mass.; United Machine & Manufacturing Co., Canton, Ohio; Westinghouse Electric & Mfg. Co., South Philadelphia, Pa.

Thermometers, Recording—The Foxboro Co., Neponset Ave., Foxboro, Mass. Leaflet describing the accuracy of the recording thermometers manufactured by them.

Screw Driver, Electric—Hisey-Wolf Machine Co., Cincinnati, Ohio. Bulletin No. 605 describes the new friction head electric screwdriver manufactured by this company.

Hoist, Gasoline.—S. Flory Manufacturing Co., Bangor, Pa. Leaflet describing the Flory hoist combined with a Fordson motor, is well illustrated and contains a table of dimensions, etc.

Regulators, Dampers — Atlas Valve Co., 282 South St., Newark, N. J. Bulletin No. 5A describes these Victor, hydraulically operated dampers for heating boilers, medium - pressure boilers and high-pressure power plants.

Filtration—Wm. B. Scaife & Sons Co., Oakmont, Pa. "Scientific Water Purification, for all Purposes," or Bulletin No. 194, covers the subject of filtration and water softening as applied in the company's systems of installations.

Coming Conventions

American Association for the Advancement of Science. Burton E. Livingston, Smithsonian Institution Washington, D. C. Meeting at Washington, Dec. 29-Jan. 3.

The American Boiler Manufacturers Association. H. N. Covell, 191 Dikeman St., Brooklyn, N. Y. Midwinter meeting at Cleveland on Feb. 12.

American Ceramic Society. R. C. Purdy, Lord Hall, Ohio State University, Columbus, Ohio. Convention at Columbus, Ohio, Feb. 16-21.

American Institute of Chemical Engineers. Dr. John C. Olsen, Polytechnic Institute, Brooklyn, N. Y. Annual meeting at Hotel Schenley, Pittsburgh, Pa., Dec. 3-6.

American Institute of Electrical Engineers. F. L. Hutchinson, 29 West 39th St., New York City. Midwinter convention at New York City, Feb. 9-13.

American Institute of Mining and Metallurgical Engineers. F. F. Sharpless, 29 West 39th St., New York City. Annual meeting at New York City, Feb. 16-19.

American Petroleum Institute. R. L. Walsh, 15 West 44th St., New York City. Annual meeting at Texas Hotel, Fort Worth, Texas, Dec. 9-11.

American Society of Heating and Ventilating Engineers. F. C. Houghten, 33 West 29th St., New York City. Annual meeting at Boston, Jan. 28-30.

American Society of Mechanical Engineers. Calvin W. Rice, 29 West 39th St., New York City. Annual meeting at New York City, Dec. 1-4.

American Society of Refrigerating Engineers. W. H. Ross, 35 Warren St., New York City. Annual meeting at New York City, Dec. 1-3.

Canadian Association of Stationary Engineers and Power Exposition. Miss Violet Pearce, 139 Essex Ave., Toronto, Ont. Convention at Windsor, Ont., June 23-25, 1925.

Eastern Ice Manufacturers Association. W. H. Ross, 35 Warren St., New York City. Eighteenth annual meeting at Hotel Chelsea, Atlantic City, N. J., Nov. 12-14.

Engineering Institute of Canada. Fraser S. Keith, 176 Mansfield St., Montreal, Que. Annual meeting at Montreal, Que., Jan. 27-29.

Exposition of Inventions. E. W. Bartlett, 47 West 34th St., New York City. Exposition at Engineering Societies Building, 29 West 39th St., New York City, Dec. 8-13.

Iowa Engineering Society. J. S. Dodds, Box 202, Ames, Iowa. Convention at Des Moines, Iowa, Jan. 27-30.

Master Boiler Makers Association. H. D. Vought, 26 Cortlandt St., New York City. Convention at Chicago, May 19-22.

National Association of Practical Refrigerating Engineers. E. H. Fox, 5707 West Lake St., Chicago, Ill. Convention at New Orleans, La., Nov. 11-14.

National Exposition of Power and Mechanical Engineering. C. F. Roth, Grand Central Palace, New York City. Annual exposition at New York City, Grand Central Palace, Dec. 1-6.

National Marine Engineers Beneficial Association. Geo. A. Grubb, 313 Machinists Building, Washington, D. C. Convention at Hotel Franklin Sq., Washington, D. C., Jan. 19.

Society of Automotive Engineers. C. F. Clarkson, 29 West 39th St., New York City. Annual meeting at Detroit, Mich., Jan. 20-23.

Society of Naval Architects and Marine Engineers. Daniel H. Cox, 29 West 39th St., New York City. Annual meeting at 29 West 39th St., New York City, Nov. 13-14.

Western Association of Electrical Inspectors. G. M. Miller, 1304 South 7th St., Louisville, Ky. Annual convention at the Brown Hotel, Louisville, Ky., Jan. 27-28.

Fuel Prices

BITUMINOUS COAL

The following table shows the trend of the spot steam market in various coals (mine run bases, f.o.b. mines):

Coal	Market Quoting	Oct. 27, 1924	Nov. 3, 1924
Pool 1	New York	$3.00	$2.50@3.00
Smokeless	Columbus	2.50	2.15@2.35
Clearfield	Boston	2.25	1.65@2.10
Somerset	Boston	2.40	1.85@2.25
Kanawha	Columbus	1.65	1.40@1.75
Hocking	Columbus	1.65	1.50@1.70
Pittsburgh No. 8	Cleveland	1.90	1.85@1.90
Franklin, Ill.	Chicago	2.50	2.25@2.50
Central, Ill.	Chicago	2.20	2.15@2.25
Ind. 4th Vein	Chicago	2.50	2.25@2.50
West Ky.	Louisville	1.80	1.50@1.75
S. E. Ky.	Louisville	1.75	1.50@1.75
Big Seam	Birmingham	1.75	1.50@1.75

FUEL OIL

New York—Nov. 6, light oil, tank-car lots; 28@34 deg. Baumé, 4¾c. per gal.; 36@40 deg. 5c. per gal., f.o.b. Bayonne, N. J.

St. Louis — Oct. 28, tank-car lots, f.o.b. St. Louis; 24@26 deg., $1.70 per bbl.; 26@28 deg., $1.75 per bbl.; 28@30 deg., $1.80 per bbl.; 30@32 deg., $1.85 per bbl.; 32@36 deg., gas oil, 4.8c. per gal.; 38@40 deg., 6c. per gal.

Pittsburgh—Nov. 3, f.o.b. local refinery; 30@34 deg., fuel oil, 5c. per gal.; 36@40 deg., fuel oil, 5¼c. per gal.

Dallas — Nov. 5, f.o.b. local refinery, 26@30 deg., $1.20 per bbl.

Philadelphia — Oct. 30, 28@30 deg., $2.10@$2.15 per bbl.; 18@22 deg., $1.87½@$1.93¾; 13@16 deg., $1.75@$1.81½ per bbl.

Boston — Nov. 5, tank-car lots, f.o.b.; heavy oil, 12@14 deg. Baumé, 4¼c. per gal.; light oil, 28@32 deg. Baumé, 5¼c. per gal.

Cincinnati — Nov. 4, tank-car lots, f.o.b. local refinery, 24@26 deg. Baumé, 5c. per gal.; 26@30 deg., 5¼c. per gal.; 30@32 deg., 5½c. per gal.

New Plant Construction

Calif., Livingston—The City plans the construction of a 50,000 gal. tank with elevation of approximately 100 ft., installing complete circulating system with 2 pumping plants, one 350 g.p.m. and 1 for emergency use. A. E. Cowell, Bank of Italy Bldg., Merced, is engineer. Bonds will probably be voted.

Calif., Los Angeles—Subway Terminal Corp., c/o Schultze & Weaver, Pacific Mutual Bldg., Archts., having plans prepared for the construction of a terminal and office building on Hill St., cost will exceed $2,000,000.

Calif., Merced—Merced Irrigation Dist., plans to extend the canal system into section near La Grande and to construct a booster pumping plant to convey water on lands. R. V. Meikle is chief engineer for the district.

Calif., Oakdale—The city plans to purchase a turbine pump delivering 600 g.p.m. G. Macomber is city engineer.

Calif., San Diego—Tia Juana River Irrigation Dist., is having plans prepared for irrigation works including pumping plant, 190 ft. head, concrete tank, 500,000 gal. capacity, reservoir, 75,000,000 gal. capacity, etc., estimated cost $200,000. J. F. Covert, National City, is engineer. Bonds will be voted to finance the project.

Calif., San Fernando—U. S. Veterans Bureau, Room 791, Arlington Bldg., Washington, D. C., F. T. Hines, Director, will receive bids until Dec. 9 for group of buildings, including heating, electrical work, elevators and refrigeration plant.

Colo., Denver—E. A. Colburn & Associates, 416 East 10th Ave., is having plans prepared for the construction of a 12 story hotel at 18th Ave. and Broadway, estimated cost $1,000,000. W. N. Bowman, Central Savings Bank Bldg., is architect.

Conn., Winsted — Strand & Sweet Mfg. Co., plans the construction of a 2 story factory, estimated cost $40,000. Owner will purchase Diesel oil engine and electric generator for 100 hp. power plant.

D. C., Washington—Harry Wardman Construction Co., 1430 K St., N. W., is having plans prepared for the construction of a hotel apartment at 16th and H Sts., N. W., estimated cost $3,000,000. Wardman & Waggaman, 1430 K St., N. W., are architects.

D. C., Washington—Walker Hotel Corporation, is having plans prepared for an addition to the hotel, 1117 Connecticut Ave., estimated cost $1,000,000. W. R. Crane, 345 Madison Ave., New York, is architect.

Fla., Tampa—Wynne-Claughton Realty Co., Atlanta, Ga., plans the construction of a 10 story hotel.

Kan., Cuba—The City plans the construction of a waterworks system, including pumping equipment, distribution mains, etc., estimated cost $40,000. C. A. Haskins, 517 Finance Bldg., Kansas City, Mo., is engineer.

Kan., Kansas City—The City, G. T. Darby, Purch. Agt., will receive bids until Nov. 13 for one 500 cu.ft. air compressor.

La., Marrero — Celotex Co., 111 West Washington St., Chicago, Ill., is having preliminary plans prepared for the construction of a plant including machinery, power equipment, etc., to manufacture board from sugar cane. Plans to raise capacity of plant from 350,000 board ft. of celotex to 1,000,000 ft. per day. Private plans. This corrects report published in Nov. 4 issue under Amesville.

Mass., Cambridge (Boston P. O.)—Eastern Steam Laundry, 941 Massachusetts Ave., plans the construction of a power and boiler house, estimated cost $45,000. Lockwood Green Co., 24 Federal St., Boston, is architect and engineer.

Miss., Hazlehurst—H. A. Mentz, Consulting Engr., Magnolia, is preparing plans for improvements to water and light plant, estimated cost $50,000.

Mo., Appleton City—The City plans an election on Dec. 2 to vote $52,000 bonds for a waterworks and distribution system including 2 deep wells, pumping equipment, etc. Burns & McDonnell, 402 Interstate Bldg., Kansas City, are engineers.

Neb., Bridgeport—The City is having preliminary plans prepared for the construction of a municipal electric light and power plant, distribution system, etc. Henningson Engineering Co., National Bldg., Omaha, is engineer.

Neb., Dunbar—H. S. Westbrook, will receive bids until Nov. 14 for pumps, motors, steel tank, tower, etc., for waterworks. Estimated cost $30,000.

Nev., Fallon—The city awarded the contract for the construction of an emergency electric power plant, to Fairbanks, Morse Co,. Spear and Harrison Sts., San Francisco, Calif., cost $48,500.

N. J., Jersey City—Plaza Apartment Hotel Corporation, c/o Clinton & Russell, 100 Maiden Lane, New York, Archts., is having plans prepared for a 15 story addition to hotel at Enos Place. Steam heating system will be installed.

N. J., Newark—Beth Israel Hospital, 651 High St., F. L. Liveright, Pres., is having plans prepared for the construction of a group of hospital buildings including separate power house, on Lyons Ave., estimated cost $2,000,000. F. Grad, 1023 Broad St., Newark, is engineer and architect.

N. J., Newark—Union Building Co., M. Rachen, Pres., c/o G. E. Jones, Union Bldg., Archt. and Engr., is having plans prepared for the construction of a 12 story office building including steam heating system, on Academy St., estimated cost $1,500,000.

N. Y., Glens Falls—The Glens Falls Hotel Corporation, awarded the contract for the construction of a 5 story hotel to contain 151 rooms, to The J. G. White Engineering Corporation, 342 Madison Ave., New York, estimated cost $500,000.

N. Y., New York—A. Bricken, 300 Madison Ave., will build a 22 story office and loft building at Broadway and 38th St., including steam heating system, estimated cost about $3,500,000. Work will be done by separate contracts under supervision of owners. Private plans.

N. Y., New York—F. T. Ley & Co., 19 West 44th St., will build a 21 story office building at Gold, John and Platt Sts., estimated cost $3,000,000. Private plans.

N. Y., New York—Ninto Building Corporation, c/o Sugarman, Hess & Berges, 18 East 41st St., Archts. and Engrs., is having plans prepared for the construction of a 15 story apartment including steam heating system, at Broadway and 94th St., estimated cost $2,500,000.

N. Y., New York—J. Polstein, 170 Broadway, is having plans prepared for the construction of a 14 story apartment house including steam heating system, on Park Ave. C. J. Jeppesen, 49 West 45th St., is engineer, G. & E. Blum, 505 5th Ave., are architects.

N. Y., Schaghticoke—The Village Clerk will receive bids until Nov. 14 for 2 triplex pumps, 75,000 gal. steel tank, etc., estimated cost $85,000. G. R. Solomon, 257 Broadway, Troy, is engineer.

Okla., Clinton—The City, W. A. Shouse, Clk., will receive bids until Nov. 14 for waterworks improvements, including 6 new deep wells, motor driven centrifugal pumps, etc. B. M. Hart, City Hall, Oklahoma City, is engineer.

Okla., Davidson—The City is having preliminary plans prepared for the construction of a water works system, including well, pump and distribution system, estimated cost $20,000. Engineer not selected.

Okla., Dustin—The City is having preliminary plans prepared for a transmission line to connect with the lines of the Oklahoma Power Co., at either Henryetta or Weleetha, including a step down transformer station, estimated cost $30,000. Engineer not selected.

Okla., Lawton — Southwestern Light & Power Co., Braniff Bldg., Oklahoma City, had preliminary plans prepared to increase the capacity of the plant here, by adding a new 500 kw. turbo steam generator set and 2 new boilers, estimated cost $200,000. E. R. Ernsberger, Continental Bldg., Oklahoma City, is engineer.

Okla., Verden—The City voted a $27,000 bond issue for a new water works system, including well, pump, motor, etc. J. C. Milliken, Chickasha, is engineer.

Okla., Wetumka—The City voted $53,000 bonds for a new water purification plant, mains, pumps, hydrants, etc., and $61,000 for new 400 hp. diesel engine electric light plant, rebuilding the electric distribution system and installing an ornamental white way. V. V. Long & Co., Colcord Bldg., Oklahoma City, are engineers.

R. I., Providence — Lying-In Hospital, Miss E. Porter, Supt., State St., awarded the contract for the construction of a 5 story hospital on Pleasant Valley Parkway, to C. B. Maguire Co., 507 Grosvenor Bldg., estimated cost $600,000 to $800,000.

S. D., Sioux Falls—The city plans to purchase an additional water pump.

Tenn., Murfreesboro—The City plans to expend $150,000 for strengthening and repairing the equipment for the water plant, and will probably purchase new force pumps, etc. J. L. Lowe, is city manager.

Tenn., Watertown—The City had preliminary plans prepared for the construction of a new water works system, including wells, pumps, motors, etc., estimated cost $60,000. Ambler Engineering Co., Richmond, Va., is engineer.

Tex., Dallas—The City, M. G. James, Secy., will purchase pump for Oak Cliff well No. 35, estimated cost $1,500.

Tex., Gonzales—Central Power & Light Co., Frost Bldg., purchased the Gonzales Water Power Co., and Gonzales Electric Light Co. & Water Works, and plans to enlarge both plants. Equipment will be purchased, including pumpers, 2 large engines for water works and generators, dynamos, etc., for electric light plant.

Tex., Paducah—The City plans an election Nov. 18 to vote on $125,000 bonds for water works improvement, including pumping equipment, etc. Gantt-Baker Co., Inc., 1116-18 West Main St., Oklahoma City, Okla., are engineers.

Tex., San Antonio—San Antonio Water Supply Co., 106 Market St., plans the construction of a new building for the Mission pumping station and doubling the size of the plant by the addition of a new well, estimated cost $50,000. Equipment including large pumper, motors, etc. will be required. R. J. Harding is general manager.

Wis., Appleton—Peterson & Wilharms, c/o A. Peterson, Route 5, plans the construction of a 2 story creamery on 2nd Ave., estimated cost $30,000 to $40,000. Architect not selected. Refrigeration and butter making machinery will be required.

Wis., Dorchester — Dorchester Canning Co., will build a cannery, warehouse and boiler house, estimated cost $75,000. Private plans.

Wis., Eden — Stephens Canning Co., O. Stephens, Elkhart Lake, will build a cannery, estimated cost $200,000. Private plans. A 300 hp. boiler, steam engine, conveying machinery, etc., will be required.

Wis., Milwaukee—The Froedtert Grain & Malting Co., is in the market for 1 air compressor for deep well air lift, including air tank. Address K. P. Froedtert president and treasurer.

Wis., Racine—St. Luke's Hospital, 13th and College Ave., awarded the contract for an addition to hospital and a central heating plant, to Bondgard & Christensen, 1135 Hound Ave. Estimated cost $200,000. E. B. Funston Co., Janes Bldg., is architect.

Wis., Shawano—The city, D. E. Wescott, Clk., will soon receive bids for the construction of a reservoir, 200,000 gal. capacity, also pumping apparatus. L. P. Polichek, Clintonville, is engineer.

Ont., Hamilton—Abso Pure Ice Co., plans the construction of an arena, estimated cost $90,000.

Ont., London—Public Utilities Comr., Utilities Bldg., plans the construction of a new hydro substation, transformers and other equipment to be installed, estimated cost $35,000. E. V. Buchanan is engineer.

S. A., Peru — Cerro de Pasco Copper Corp., 15 Broad St., New York, will soon receive bids for electrical equipment for Cottrell precipitation plant, including miscellaneous motors, rectifiers, transformers high tension insulators, etc.

PRICES - MATERIALS - SUPPLIES

Electrical prices on following page are prices to the power plant by jobbers in the larger buying centers east of the Mississippi. Elsewhere the prices will be modified by increased freight charges and by local conditions.

SINCE LAST MONTH

Advances are slightly in excess of declines in the present market for power-plant and electrical supplies compared with last month. Conduit prices underwent a complete revision downward. Advances of ½c. per lb. for red and white lead and 5c. per gal. for linseed oil were reported for New York; Cleveland shows a rise of 5½c. for the babbitt metal 83% tin and 1c. per lb. for the 35% tin; rivets advanced 15c. per 100 lb. in Chicago.

POWER-PLANT SUPPLIES

HOSE—Quotations at New York warehouses:

	Fire Protection	50-Ft. Lengths
Underwriters' 2½-in., coupled, sing'e jacket		56c. per ft.
Common, 2½-in., 3-ply	80c. per ft. list less	50–10%

Air—Best grade

¼-in., per ft.	3-ply	$0.36	4 ply	$0.44½

Steam—Discounts from List

First grade	30–5%	Second grade	40–5%	Third grade 50%

RUBBER BELTING—List price 6-in., 6 ply, $1.83 per lin.ft. The following discounts from list apply to rubber transmission belting:

Best grade	50%	Second grade	50–10%

LEATHER BELTING—List price, 24c. per lin.ft. per inch of width for single ply at New York warehouses.

Grade	Discount from list
Medium	40–2½%
Heavy	30–5%

RAWHIDE LACING—For cut, best grade, 45–5%, 2nd grade, 55%. For laces in sides, best, 41c. per sq.ft.; 2nd, 37c. Semi-tanned: cut, 45–5%; sides, 41c. per sq.ft.

PACKING—Prices per pound at New York warehouses:

Rubber and duck for low-pressure steam, ⅛ in.	$0.90
Asbestos for high-pressure steam, ⅛ in.	1.70
Duck and rubber for piston packing	.90
Flax, regular	1.10
Flax, waterproofed	1.70
Compressed asbestos sheet	.80
Wire insertion asbestos sheet	1.30
Rubber sheet	.45
Rubber sheet, wire insertion	.70
Rubber sheet, duck insertion	.50
Rubber sheet, cloth insertion	.25
Asbestos packing, twisted or braided and graphited, for valve stems and stuffing boxes	1.30
Asbestos wick, ½- and 1-lb. balls	.50

PIPE AND BOILER COVERING—Discounts, New York warehouses, are as follows:

85% magnesia high pressure		50%
For low-pressure heating and return lines	4-ply	70%
	3-ply	72%
	2-ply	74%

PORTLAND CEMENT—New York, $2.50@ $2.60 per bbl. without bags, in carload lots delivered on job. Bag charge of 40c. per bbl.

STRUCTURAL STEEL—New York delivered price, 3 to 15-in. beams and channels and 3 to 6-in. angles, tees, and plates, all $3.34 per 100 lb.

COTTON WASTE—The following prices are in cents per pound:

	New York	Cleveland	Chicago
White	14@21	19.00	14.00
Colored	9@14.50	18.00	10.50

WIPING CLOTHS—Jobbers' prices, in cents per lb., as follows:

	13½ x 13½	13½ x 20½
Chicago	16.00	16.00
New York (white, at washeries)	11.00@11.25	.....
Cleveland	$36.00 per M.	$50.00 per M.

LINSEED OIL—These prices are per gallon:

	New York	Cleveland	Chicago
Raw in barrels (5 bbl. lots)	$1.08	$1.16	$1.05

WHITE AND RED LEAD—In 100-lb. kegs, base price in cents per pound:

	Dry		In Oil	
	Current	1 Yr. Ago	Current	1 Yr. Ago
Red	15.25	14.00	16.75	15.50
White	15.25	14.00	15.25	14.00

RIVETS—The following quotations are allowed for fair-sized orders from warehouse:

	New York	Cleveland	Chicago
Steel ⅛ and smaller	60%	60–10%	70%
Tinned	60%	60–10%	70%

Structural rivets, ½ in. diameter by 2 in. to 5 in. sell as follows per 100 lb.

New York	$3.75	Chicago	$3.65	Pittsburgh $2.60

Boiler rivets, same sizes:

New York	$3.85	Chicago	$3.75	Pittsburgh $2.90

REFRACTORIES—Prices in car lots f.o.b. plant:

Chrome brick, eastern shipping points	net ton	$47@52
Chrome cement, 40@ 50% Cr_2O_3, in bulk	net ton	22@27
Chrome cement, 40@ 50% Cr_2O_3, in sacks	net ton	26@31
Magnesite brick: 9-in. straights	net ton	65@68
Magnesite brick: 9-in. arches, wedges and keys	net ton	71.50@74.80
Magnesite brick: Soaps and spits	per ton	91.00@95.20
Silica brick: Mt. Union, Pa.	per M	38@40
Clay brick, 1st quality, 9 in. shapes, Pennsylvania	per M	40@47
Clay brick, 1st quality, 9 in. shapes, Ohio	per M	40@43
Clay brick, 1st quality, 9 in. shapes, Kentucky	per M	42@43
Clay brick, 2nd quality, 9 in. shapes, Pennsylvana	per M	35@42
Clay brick, 2nd quality, 9 in. shapes, Ohio	per M	37@39
Clay brick, 2nd quality, 9 in. shapes, Kentucky	per M	37@39
Chrome ore crude, 40@50%	net ton	17.00@19.50

BABBITT METAL—Warehouse prices in cents per pound:

	New York	Cleveland	Chicago
(83% tin)	60.00	62.50	48@52
(35% tin)	28.00	19.50	23@26

COLD DRAWN STEEL—Warehouse prices are as follows:

	New York	Cleveland	Chicago
Round shafting and screw stock, per 100 lb. base	$4.05	$3.90	$3.80
Flats, squares and hexagons, per 100 lb. base	4.55	4.40	4.30

BOILER SPECIALTIES—F. o. b. New York or Jersey City, discounts on list:

	Current
Copper ferrules	70%
Boiler flanges	60-10%
Boiler stay bolts	60%
Boiler patch bolts	10%
Boiler fitting-up bolts	45%
Pressed steel boiler lugs	10%
Pressed steel boiler hangers	10%

WROUGHT PIPE—The following discounts are to jobbers for carload lots at Pittsburgh mill:

BUTT WELD

Inches	Steel Black	Steel Galv.	Inches	Iron Black	Iron Galv.
1 to 3	62	50½	1 to 1½	30	13

LAP WELD

2	55	43½	2	23	7
2½ to 6	59	47½	2½	26	11
7 and 8	56	43½	3 to 6	28	13
9 and 10	54	41½	7 to 12	26	11
11 and 12	53	40½			

BUTT WELD, EXTRA STRONG, PLAIN ENDS

1 to 1½	60	49½	1 to 1½	30	14
2 and 3	61	50½			

LAP WELD, EXTRA STRONG, PLAIN ENDS

2	53	42½	2	23	9
2½ to 4	57	46½	2½ to 4	29	15
4½ to 6	56	45½	4½ to 6	28	14
7 and 8	52	39½	7 and 8	21	7
9 and 10	45	32½	9 to 12	16	2
11 and 12	44	31½			

BOILER TUBES—Following are prices in New York warehouse of tubes manufactured according to specifications of the American Society of Mechanical Engineers:

Size	Lapweld Steel	C. C. Iron	Seamless Steel
1	.....	.....	$0.23
1¼	.....	.....	.25
1½	.....	.....	.22
1¾	.....	.....	.....
1¼	$0.26	$0.29	.23
2	.20	.25	.21
2½	.23	.29	.23
2½	.24	.33	.28
2¾	.....	.....	.....
3	.30	.41	.32
3½	.32	.47	.35
3½	.34	.51	.37
4	.43	.64	.47

Tubes 2½ in. diameter, or smaller, over 18 ft. long, 10 per cent extra.

These prices are net per lineal foot based on stock lengths. If cut to special lengths, billing will be based on the entire stock lengths.

In addition to the above, standard cutting charges are as follows:

1¼ in. to 2 in. diameter, 5c. per cut. 2½ in. diameter, 7c. per cut
2½ in. diameter, 6c. per cut. 3 in. diameter, 9c. per cut
3½ in. to 4 in. diameter, 10c.

ELECTRICAL SUPPLIES

ARMORED CABLE—Price per 1,000 ft.—5 per cent 10 days.

B. & S. Size	Two Cond. M Ft.	Three Cond. M Ft.	Two Cond. Lead M Ft.	Three Cond. Lead M Ft.
No. 14 solid	$40.00 (net)	$ 56.50 (net)	$164.00	$210.00
No. 12 solid	135.00	170.00	225.00	265.00
No. 10 solid	185.00	235.00	275.00	325.00
No. 8 stranded	285.00	375.00	520.00	500.00
No. 6 stranded	400.00	500.00	560.00	.....

From the above lists discounts are:		Lead Covered
Less than coil lots	45%	25%
Coils to 1,000 ft.	50%	30%
1,000 to 5,000 ft.	55%	35%
5,000 ft. and over	60%	40%

CONDUIT, Price per 1,000 ft.; **ELBOWS AND COUPLINGS**, Per 100 pieces, f.o.b. New York, with 10-day discount of 5 per cent.

Size In.	Conduit Black Per M	Conduit Galvanized Per M	Elbows Black Per C	Elbows Galvanized Per C	Couplings Black Per C	Couplings Galvanized Per C
½	$58.92	$63.77	$9.56	$10.64	$5.52	$5.92
¾	75.35	81.90	12.58	14.01	7.88	8.45
1	108.15	117.84	18.62	20.73	10.25	10.99
1¼	146.33	159.44	24.78	27.35	14.21	15.18
1½	174.96	190.63	33.04	36.46	17.55	18.75
2	235.39	256.48	60.58	66.85	23.41	25.00
2½	372.18	405.52	99.13	109.39	33.43	35.71
3	486.69	530.30	264.34	291.70	50.14	53.56
3½	611.52	663.96	583.74	644.16	66.86	71.42
4	745.53	807.36	674.61	774.43	83.57	89.27

CONDUIT BODIES AND FITTINGS—Black or galvanized.

	Less than $10 list	$10 list to $100	$100 list and over
Standard package	10%	20%	28%
Less than standard package	5%	10%	20%

CUT-OUTS—Following are net prices each in standard-package quantities:

CUT-OUTS, PLUG

S. P. M. L.	$0.12	D. P. D. B.	$0.31
D. P. M. L.	.16	T. P. S. B.	.35
T. P. M. L.	.27	T. P. D. B.	.47
D. P. S. B.	.16		

CUT-OUTS, N. E. C. FUSE

	0-30 Amp.	31-60 Amp.	60-100 Amp.
D. P. M. L.	$0.27	$0.70	$1.75
T. P. M. L.	.40	1.00	2.30
D. P. S. B.	.35	.87	.....
T. P. S. B.	.67	1.50	.....
D. P. D. B.	.65	1.75	.....
T. P. D. B.	1.12	3.00	.....
T. P. to D. P. D. B.	.75	2.10	.....

FLEXIBLE CORD—Price per 1,000 ft. in coils of 250 ft.:

No. 18 cotton reinforced heavy	$21.00
No. 16 cotton reinforced heavy	24.00
No. 18 cotton reinforced light	17.00
No. 16 cotton reinforced light	20.50
No. 18 cotton Canvasite cord	16.50
No. 16 cotton Canvasite cord	18.75

NATIONAL ELECTRIC CODE FUSES, NON-REFILLABLE—

250-Volt	Std. Pkg.	List	600-Volt	Std. Pkg.	List
3-amp. to 30-amp.	100	$0.15	3-amp. to 30-amp.	100	$0.30
35-amp. to 60-amp.	100	.30	35-amp. to 60-amp.	100	.60
61-amp. to 100-amp.	50	.90	65-amp. to 100-amp.	50	1.50
101-amp. to 200-amp.	25	2.00	110-amp. to 200-amp.	25	2.50
201-amp. to 400-amp.	25	3.60	225-amp. to 400-amp.	25	5.50
401-amp. to 600-amp.	10	5.50	450-amp. to 600-amp.	10	8.00

Discount: Less 1-5th standard package, 55%; 1-5th to standard package, 60%; standard package, 65%.

RENEWABLE FUSES, ENCLOSED—List price each:

Sizes	250-Volt List-Price	600-Volt List-Price	Std. Pkg. Quantity	Carton Quantity
1 to 30-amp.	$0.50	$1.10	100	10
35 to 60-amp.	1.00	1.25	100	10
65 to 100-amp.	2.00	3.00	50	5
110 to 200-amp.	4.00	5.00	25	5
225 to 400-amp.	7.50	11.00	25	1
450 to 600-amp.	11.00	16.00	10	1
450 to 600-amp.	11.00	16.00	10	1

REFILLS—

1 to 30	$0.30 ea.	$0.05	100	100
35 to 60	.05 ea.	.06	100	100
65 to 100	.10 ea.	.10	50	50
110 to 200	.15 ea.	.15	25	50
225 to 400	.30 ea.	.30	25	25
450 to 600	.60 ea.	.60	10	10

Discount Without Contract—Fuses:	
Broken carton	5%
Unbroken carton but less than std. pkg.	22%
Std. pkg.	40%
Discount Without Contract—Renewals:	
Less than std. pkg.	Net list
Standard package	40%
Discount With Contract—Fuses:	
Broken cartons	10%
Unbroken cartons but less than standard package	26%
Standard package	42%
Discount With Contract—Renewals:	
Less standard package	Net list
Standard package	42%

FUSE PLUGS, MICA CAP—

0–30 ampere, standard package (500)	$2.85
0–30 ampere, less than standard package	3.15

LAMPS—Below are present quotations in less than standard package quantities:

Straight-Side Bulbs Mazda B— Watts	Plain	Frosted	No. in Package	Pear-Shaped Bulbs or Bowl Enameled Mazda C— Watts	Clear	Frosted	No. in Package
10	$0.27	$0.32	120	50	$0.40	$0.45	60
15	.27	.32	120	75	.45	.55	60
25	.27	.32	120	100	.55	.60	24
40	.27	.32	120	150	.70	.75	24
50	.27	.32	120	200	.95	1.05	24
60	.32	.37	120	300	1.50	1.60	24
				500	2.25	2.40	12
				750	3.75	3.95	8
				1,000	4.00	4.25	8

Standard quantities are subject to discount of 10% from list. Annual contracts ranging from $75.00 to $300,000 net allow a discount of 15 to 40% from list.

PLUGS, ATTACHMENT—

	Each
Porcelain separable attachment plug	$0.18
Composition 2-piece attachment plug	.27
Swivel attachment plug	.12
Small size—2 Pc. Plug—Composition	.08½

RUBBER-COVERED COPPER WIRE—Per 1000 ft. f. o. b. New York:

No.	Solid Single Braid	Solid Double Braid	Stranded, Double Braid	Duplex
14	$6.70	$8.60	$10.40	$16.75
12	8.90	11.50	13.00	21.00
10	11.20	14.95	16.50	28.50
8	16.50	19.85	22.05	38.50
6	.....	.....	31.25	.....
4	.....	.....	42.50	.....
2	.....	.....	62.25	.....
1	.....	.....	80.53	.....
0	.....	.....	108.50	.....
00	.....	.....	128.50	.....
000	.....	.....	153.00	.....
0000	.....	.....	184.50	.....

SOCKETS, BRASS SHELL—

½ In. or Pendant Cap Key Each	Keyless Each	Pull Each	¾ In. Cap Key Each	Keyless Each	Pull Each
$0.33	$0.30	$0.55	$0.39	$0.36	$0.61

Less 1-5th standard package	25%
1-5th to standard package	32%
Standard package	37%

WIRING SUPPLIES—

Friction tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Rubber tape, ¾ in., less 100 lb. 33c. lb., 100 lb. lots	31c. lb.
Wire solder, less 100 lb. 27c. lb., 100 lb. lots	29c. lb.
Soldering paste, 2 oz. cans	$1.00 doz.

ENCLOSED SWITCHES, KNIFE—Safety type, externally operated, 250 d.c. or a.c., N.E.C.

TYPE "C" FUSED BOTTOM

Size, Amp.	Double Pole, Each	Three Pole, Each	Four Pole Each
30	$4.50	$6.00	$7.25
60	7.50	8.25	10.50
100	10.50	13.00	22.50
200	16.00	20.00	36.00

Discounts:	
Less than $25.00 list value	30%
$25 to $50 list value	30–5%
$50 list value or over	35%